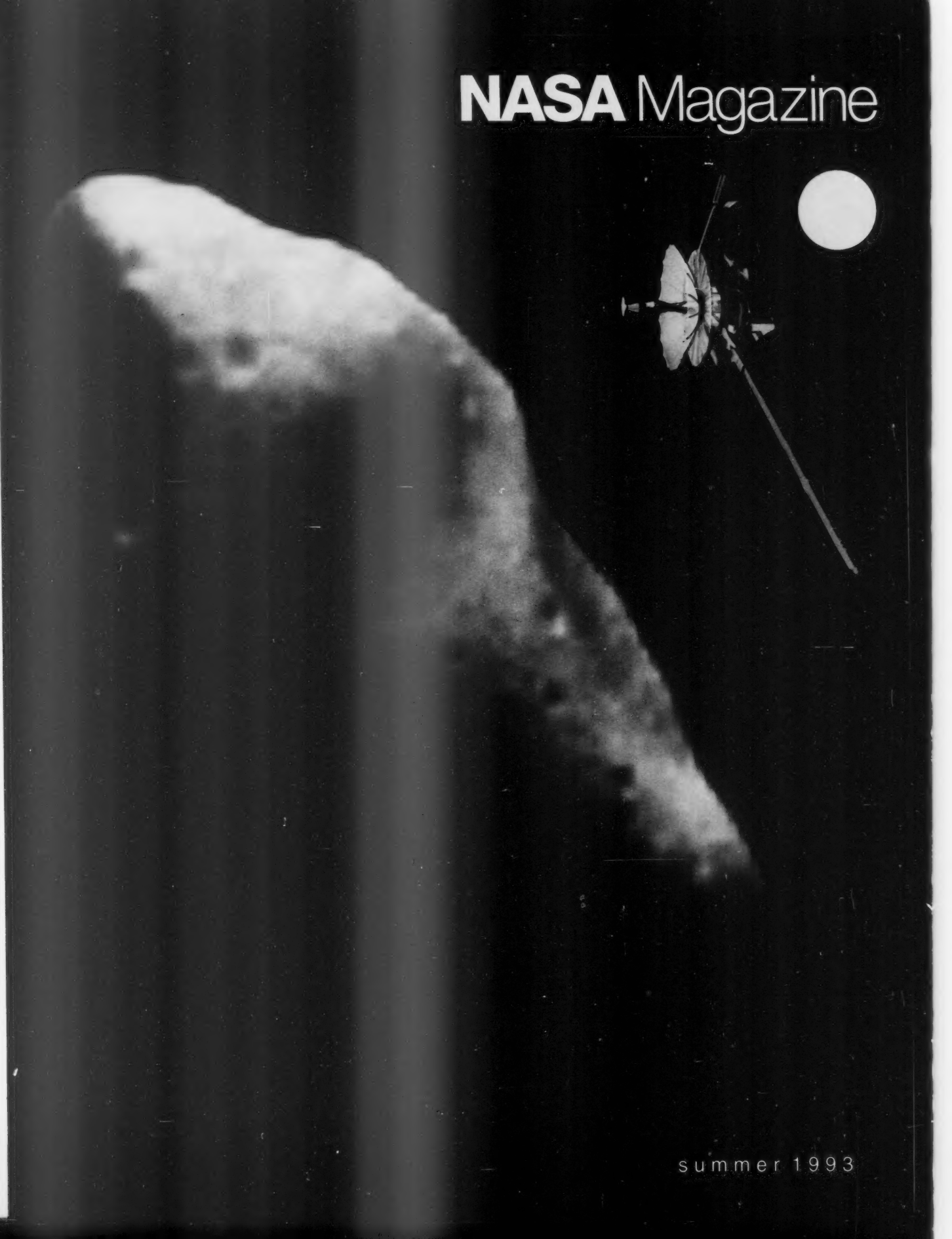
# NASA Magazine



summer 1993

# from the administrator

The most fruitful intersection of NASA's mandates for change likely will be in the area of small scientific satellites, and I am tremendously excited by the possibilities.

In this issue of *NASA Magazine*, we celebrate exciting scientific observations made by the Galileo spacecraft bound for Jupiter and the TOPEX/POSEIDON satellite mapping Earth's oceans. By the end of their stellar missions, each of these spacecraft will have earned a rightful place in the "Hall of Fame" for robotic space explorers.

However, after their compatriot Cassini leaves Earth in 1997 on its way to survey Saturn and its intriguing moon Titan, it may be a long while before such a combination of scientific merit and adequate funding intersects again.

The combination of federal budget constraints, a need to improve our links with universities, and President Clinton's challenge to NASA to pursue more industrially relevant advanced technology presents us with an ideal way to re-establish the Agency's "can-do" reputation: the development of a diverse fleet of small Earth-orbiting and planetary science spacecraft.

Very few things that NASA has proposed in the past decade have stirred as much interest within the space science community as the Discovery small spacecraft program that we will pursue in earnest this year.

The top 11 proposals that recently won $100,000 each in study money include two missions to Mercury, two to Venus, one to Mars, four missions to small bodies, an Earth-orbiting telescope to study Jupiter and a solar wind sample return. Think of the scientific enigmas that could be solved by such an incredible fleet!

In a separate effort, an enthusiastic and innovative group out at the Jet Propulsion Laboratory is pursuing a cheap and fast mission to Pluto, a project with natural scientific and public appeal.

Our Office of Mission to Planet Earth, already well-known for its Earth Probe series, is considering a smaller follow-on to TOPEX/ POSEIDON, and a second tropical rainfall-measuring satellite to succeed the TRMM Earth Probe we are building jointly with Japan.

Small satellites are attractive for many reasons, but two stand out. First, they force us to design components that are cheaper, lighter and use less electrical power.

Second, small satellites are an ideal match with the needs of the university community, which needs manageably priced hardware projects that start and finish within the academic lifetime of a graduate student. We are going to prove this new technology before we proceed with a mission by making reasonable investments in technology test beds. And when we start a flight project, we are going to sign up to a budget and live with it.

I explained NASA's commitment to this philosophy during a hearing before the House Appropriations subcommittee with NASA oversight. The panel's chairman, Rep. Louis Stokes, said that if NASA could sign up to do that with small programs, the committee would consider multi-year funding. That is a wonderful trade.

A Russian expert on the history of science in his culture once wrote, "Every scientist is an agent of cultural change. He [or she] may not be a champion of change, he may even resist it. But to the extent that he is a true professional, the scientist is inescapably an agent of change. His tools are the instruments of change: skepticism, the challenge to established authority, criticism, rationality and individuality."

The most fruitful intersection of NASA's mandates for change likely will be in the area of small scientific satellites, and I am tremendously excited by the possibilities.

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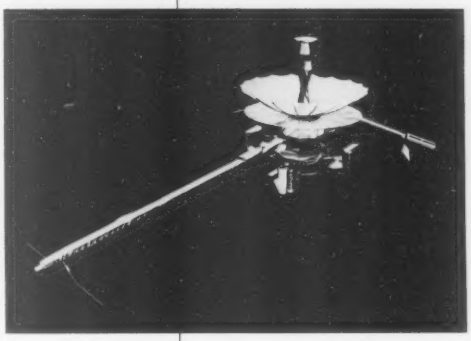

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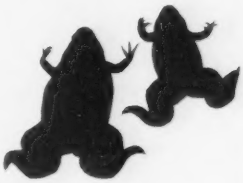

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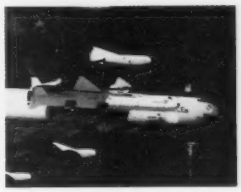


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*Acting Associate Administrator for Public Affairs*
Geoffrey H. Vincent

*Acting Manager of Internal Communications*
Beth Schmid

*Editor*
Beth Schmid

*Staff Writer*
Doug Isbell

*Editorial Consultant*
Tony Reichhardt

*Editorial and Production Assistant*
Sonja Alexander

*Design*
Steve Chambers

*Art Director*
Robert Schulman

*Staff Photographer*
Bill Ingalls

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*John H. Casper and Sidney M. Gutierrez*

### Two New Crews

Astronaut crews for two Space Shuttle missions scheduled for launch early next year were selected in March. Air Force Col. John H. Casper will command the STS-62 mission with the second U.S. Microgravity Payload onboard Columbia. Other crew members are Marine Corps Maj. Andrew M. Allen as pilot and Navy Cdr. Pierre J. Thuot, Army Lt. Col. Charles D. "Sam" Gemar and Marsha S. Ivins as mission specialists.

Experiments on STS-62, a 13-day extended duration orbiter mission, include growing crystals of semiconductor materials; investigating the properties of xenon during phase transitions; studying the fundamental behavior of materials as they solidify, and monitoring equipment that will measure and record disturbances in the microgravity environment onboard the Shuttle.

Air Force Col. Sidney M. Gutierrez will command the STS-59 Space Radar Laboratory mission onboard Atlantis, with Air Force Col. Kevin P. Chilton as pilot. Mission specialists Jay Apt, Ph.D., and Army Lt. Col. Michael R. "Rich" Clifford will join Linda M. Godwin, Ph.D., and Thomas D. Jones, Ph.D., who were assigned to the flight previously.

STS-59's Space Radar Laboratory will take radar images of the Earth's surface for studies in geology, geography, hydrology, oceanography, agronomy and botany. The mission also will measure carbon dioxide in the atmosphere and gather data for designing future radar systems, including that of NASA's Earth Observing System.

### Fame

A "cool suit" originally developed to keep astronauts from overheating on the Moon and a NASA patient monitoring device were inducted into the U.S. Space Foundation's Technology Hall of Fame in April.

Worn inside an astronaut's space suit, the liquid-cooled garment used a battery-powered pump to circulate chilled water through a series of tubes. Although it was developed at the Ames Research Center and Johnson Space Center for the Apollo program, the technology was later adapted by the Langley Research Center to meet real-life needs. The cool suit is now used by patients suffering from cystic fibrosis, multiple sclerosis (MS) and related neurologic disorders, and a condition known as hypohidrotic ectodermal dysplasia, in which the body lacks sweat glands. Since 1991, approximately 300 suits have been sold to MS patients alone. Army soldiers wore the liquid-cooled garments during the Persian Gulf war, and they also have been worn by race car drivers, hazardous materials handlers, nuclear reactor workers, and paper mill and shipyard personnel.

The patient-monitoring device originally was developed during the Mercury and Gemini programs by the U.S. Air Force. Engineers at Johnson then improved the technology, using it to transmit medical data from astronauts back to Earth. The system, still used for astronaut monitoring today, has been widely used around the world. Thanks to telemetry, a nurse at a central station can simultaneously monitor the conditions of several patients at different locations. This enables heart patients, for example, to return home and still receive constant medical monitoring.

### Stargazing at Mach 3

One of NASA's high-flying SR-71A "Blackbirds" (*NASA Magazine*, Winter 1992) has a new mission: conducting high-altitude astronomy studies at three times the speed of sound. The former spy plane, which is based at the Dryden Flight Research Facility, made its first science flight on March 9 with an ultraviolet video camera for studying stars and comets riding in its nose bay.

Future flights will carry a variety of instruments, including a fiber optics device and an ultraviolet spectrom-

*SR-71 streaks into the twilight on its first science mission last March.*

eter. SR-71 project scientist Jacklyn Green of the Jet Propulsion Laboratory, where the experiments were developed, said this is a "case of turning swords into plowshares."

"We are taking what was once a spy plane and transforming it into a useful, cost-effective science platform," says Green. "This opens up a new ultraviolet window for research." During its first mission, the SR-71 climbed to an altitude of more than 25 kilometers, above most of the atmosphere that blocks ground-based ultraviolet observations.

The flight could mark the beginning of a whole new science career for the SR-71. Several other experiments are now in the planning stage, including infrared studies of the aurora borealis and studies of pollutants in the stratosphere. NASA's three Blackbirds also may serve as platforms for aeronautics studies in NASA's High-Speed Research Program.

## High Speed Research

NASA is teaming up with U.S. industry to develop technology for an affordable and environmentally friendly high-speed passenger aircraft that could revolutionize air travel in the next century. The Langley Research Center will lead the multi-year High Speed Civil Transport research program, which will provide a technical foundation for U.S. aerospace companies to make business decisions about future supersonic transports.

Langley researchers are working on ways to reduce the overall structural weight and improve aerodynamic performance for such a vehicle. Engineers at the Lewis Research Center are working on technology that will reduce engine noise and dramatically lower nitrogen oxide emissions that might affect Earth's ozone layer.

Ames and Dryden also are involved in the project, with Ames flying high-altitude missions to analyze the impact of engine exhaust on the atmosphere, and Dryden testing a drag-reduction concept called "laminar flow control," which could significantly improve the efficiency of a supersonic transport's wings.

Phase I of the program, which focuses on environmental challenges, runs until 1996. Phase II, which began this year, focuses on technology that would make a high-speed transport economically viable.

## Early Bird Catches Earlier Data

The Jet Propulsion Laboratory reported in March that due to surplus fuel reserves on the Mars Observer spacecraft, the spacecraft will begin mapping operations sooner than expected. Science operations are now planned to begin on November 22, three weeks ahead of schedule. Mars Observer is set to arrive at the planet on August 24.

The mission operations team wants to ensure that data collection is well underway before two natural events occur: a December 1993 solar conjunction that will block spacecraft communications, and the beginning of the Martian dust storm season next February.

By spending the extra fuel for a so-called "power-in" approach, the spacecraft's descent to its mapping orbit 378 kilometers above the Martian surface will take only 75 days instead of 96 days. Then, after two weeks of checkout, the spacecraft will begin observing Mars, completing one full mapping cycle—which takes 26 days—before

*Mars Observer*

the solar conjunction starts on December 20. The conjunction will last through January 3, during which time all radio commands to the spacecraft will be suspended.

### Saving Grapes

The Ames Research Center is using aerial and satellite images to help battle a serious insect problem facing California's $10 billion-a-year wine industry. A team that includes the Robert Mondavi Winery in Napa Valley and researchers from three California universities will be aided in their fight against root louse damage by sensitive electronic scanners on aircraft and satellites.

About 65 percent of the vineyards in Napa and Sonoma counties are planted with a grape rootstock vulnerable to a new strain of phylloxera, an aphid-like insect that kills grapevines by sucking juice from the plants' roots. The bug nearly destroyed the vineyards of France and California more than a century ago, causing severe economic hardship.

Joan Salute, Ames Project Manager for the Grapevine Remote Sensing Analysis of Phylloxera Early Stress (GRAPES) project, says that remote sensors can detect plant stress before it is visible to the naked eye.

"This will help vineyard managers develop replanting plans," says Salute. "Replanting with resistant roots is the only way to rid the vineyards of the pest."

Field work using ground-based scanners to make initial measurements of leaves began in April as the leaves were developing. Images from infested and non-infested grapevines continue to be analyzed to determine the earliest detectable spectral differences. The first remote sensing flights are scheduled this summer as the grapevine foliage increases.

Mondavi, which plans continued use of the technology, will make the results of the jointly financed $350,000-a-year, three-year study available to other wine growers. According to Phil Freese, Mondavi's Vice President for wine growing, replanting the vineyards costs about $20,000 an acre, so it is critical to understand the spread of new infestation sites.

Funding for the GRAPES project is provided by NASA's Office of Advanced Concepts and Technology as a demonstration of new remote sensing applications for industry.

### Wet World?

Data returned by the Pioneer Venus Orbiter before it burned up in the Venusian atmosphere last October suggest that the planet, which is now a hot desert, once had three and a half times more water than previously thought. According to Thomas Donahue of the University of Michigan, who heads the Pioneer Venus science steering group, "Findings that Venus was once fairly wet do not prove that major oceans existed, but makes their existence far more likely. The new Pioneer data provide evidence that large amounts of water were definitely there."

Deuterium, a heavy form of hydrogen, normally is found in a specific ratio with ordinary hydrogen. But deuterium on Venus is 150 times more

*Artist's conception of the Pioneer Venus Orbiter against the Venusian background.*

abundant relative to hydrogen than it is on Earth. The new data suggest that this may not always have been the case.

"We found a new and important easy-escape mechanism, which accelerates hydrogen and deuterium away from the planet," says Donahue. "This means that much more hydrogen had to escape to build up the present high deuterium concentration. A lot more hydrogen lost means a lot more water early on."

## Diamonds in the Sky

Huge amounts of microscopic diamonds discovered in star-forming clouds in the Milky Way present a new challenge to theories of how galaxies evolve.

Scientists from the Ames Research Center had been expecting to find "simpler forms of hydrocarbons, molecules that make up materials similar to candle wax or gasoline" in the dense clouds, according to Lou Allamandola, head of the science observation team. But instead they found large quantities—the equivalent of planetary masses—of micro-diamonds dominating every cloud they observed.

The Allamandola team puzzled for more than a year before identifying the micro-diamonds. Having observed a prevalence of softer hydrocarbons in regions between the clouds, they had expected those materials to be common inside the clouds as well. The finding means that astronomers will have to revise their ideas about how matter moves in and out of the clouds.

"This shoots a hole in a major premise of galactic chemical evolution theories," says science team member Scott Sandford.

## Happy Birthday, TDRSS

April marked the 10th anniversary of NASA's Tracking and Data Relay Satellite System, a revolutionary "switchboard in space" that keeps the Space Shuttle and other orbiting spacecraft in near-constant touch with Earth. The TDRSS replaced a ground-based network developed in the early days of the space program that allowed spacecraft to communicate with Earth only on those rare occasions when they were in sight of a tracking station.

The first TDRS satellite was launched from the Shuttle in April 1983. Since then, four more satellites have been put into orbit, the latest in January of this year. The existing system, which includes backups, should serve NASA's communications needs into the later part of this decade.

The TDRSS enables uninterrupted, real-time communications with up to 24 spacecraft simultaneously. At its highest capacity, the system can transfer the equivalent of a 20-volume encyclopedia—containing over 34 million words—each second.

## To Mars With Russia

NASA Administrator Dan Goldin and Russian Space Agency Director Yuri Koptev signed a contract in April to fly two U.S. instruments on the Russian Mars '94 mission planned for launch in November 1994. The mission will deploy small landing stations and penetrators and carry a complement of instruments to study the surface and atmosphere of Mars.

Under the contract, which has a potential value of $1.5 million, the Babakin Engineering Research Center and the Space Research Institute of the Russian Academy of Sciences will provide technical services for integrating and testing the U.S. Mars Oxident Experiment (MOX) instruments. A duplicate MOX instrument will fly on each of the two Russian small stations. The experiment will provide chemical information about the Martian soil and will enable scientists to characterize the physical and chemical nature of the planet's surface.

### The Big Red Supergiants

Scientists have long theorized that red supergiants—stars with diameters as large as Jupiter's orbit around the Sun—end their existence in massive explosions called supernovas. Now, thanks to the International Ultraviolet Explorer's observation of a new supernova on March 30, they have direct evidence.

According to George Sonneborn, an IUE research scientist at the Goddard Space Flight Center, the discovery substantiates decades of work in stellar structure theory. The supernova's nearness and the quickness with which IUE was able to observe it were critical factors in determining that the exploding star is surrounded by a thick shell of slowly expanding gas. Heated to very high temperatures by the enormous energy released in the explosion, the ultraviolet emissions from the glowing gas were detected by IUE.

Scientists expect to gain a wealth of new knowledge from studying the supernova, which occurred about 12 million lightyears from Earth in a galaxy known as M81 in the constellation of Ursa Major. Sonneborn says the "stellar wind" flowing outward from the explosion will tell scientists much about the late stages of a star's life.

### Oh My Darlin'...

NASA announced in April that Eugene Shoemaker of the U.S. Geologic Survey in Flagstaff, Ariz., will head the science team for the upcoming Clementine mission to orbit the Moon and fly past an asteroid. Clementine, sponsored by the Strategic Defense Initiative Office, will launch a small spacecraft in January 1994 to orbit the Moon for several months, gathering geological data. The spacecraft would then fly by the near-Earth asteroid 1620 Geographos on August 31, 1994, when the asteroid is at its closest approach to Earth.

The goals of the mission are to test new, lightweight sensors in a space radiation environment and to demonstrate autonomous navigation and spacecraft operation. Lightweight and innovative spacecraft components also will be tested, including a star tracker, an inertial measurement unit, reaction wheels for attitude control, a nickel hydrogen battery and solar panels.

The science team is planning for the acquisition of science data as well as the archiving and initial analysis of those data. The Naval Research Laboratory is responsible for designing the mission, providing the spacecraft and conducting mission operations. The Jet Propulsion Laboratory will be responsible for tracking the spacecraft using NASA's Deep Space Network and for locating Geographos using its Near Earth Object Center prior to the flyby.

*Aboard Discovery, astronaut J. Michael Foale, talks to amateur radio operators via SAREX.*

### Shuttling Vicariously

Of the many stories surrounding the successful STS-56 mission in April, one involves students within the Alabama, Mississippi and Tennessee area. Students from NASA's Tri-State Education Initiative (TSEI) region had three different chances to experience STS-56 activities. First, 17 students traveled to the Kennedy Space Center to witness Discovery's lift-off on April 8. Two days later, 2,000 students gathered in a high school gymnasium to speak to the STS-56 crew via ham radio.

NASA's TSEI area was selected in a national competition as one of 12 sites to participate in the Shuttle Amateur Radio Experiment (SAREX) by the American Radio Relay League and NASA. Twenty-one students acted as representatives for the whole group, asking questions of all the astronauts. Another 30 students quizzed the astronauts via satellite link from Mississippi, in a brief but unforgettable exchange with the crew. •

## Honored

**Catherine G. Schauer**, a public affairs specialist at the Langley Research Center, received two first place state awards in the Virginia Press Women's annual communications contest in April. The awards were in Institutional Relations, Government, for her role as the center's chairman and project manager of its 75th anniversary-year Open House brochure. Each entry now goes on to compete at the national level for a National Federation of Press Women award.

At the 45th annual presentation of the Arthur S. Flemming Awards for excellence in government service in May, two NASA employees received recognition. Dryden's **Marta R. Bohn-Meyer** was awarded for her outstanding achievements as a NASA scientist who distinguished herself in the field of flight research. Bohn-Meyer is the only woman in the world to have actively performed the role of Flight Test Engineer in the Mach 3+ SR-71, and her recent publication, "...and She Flies Well Too," was requested by the Office of the Secretary of the Air Force for use in preparing its public statement on women in combat.

Ames' **William Warmbrodt** was awarded for his outstanding technical and managerial leadership in developing the only large-scale wind tunnel rotorcraft test capability in the United States; for his expert guidance in using this capability to support several NASA, industry and Department of Defense rotorcraft test programs; and for entering into a partnership with the rotorcraft technical community to improve the competitive position of United States industry.

Forty-three NASA managers received the 1992 Presidential Rank Award last April in recognition of sustained extraordinary career accomplishments. Ten honorees received the Distinguished Executive Rank Award, which includes an award of $20,000, and 33 received the Meritorious Executive Rank Award and $10,000. The Distinguished Executive awardees from Headquarters are: Robert Brown, Bill Colvin, and Edward Frankle; from Goddard: Robert Baumann; from Johnson: Henry Pohl and Paul Weitz; from Langley: Robert Swain; from Lewis: Neal Saunders; and from Marshall: George McDonough and Susan McGuire Smith. The Meritorious Executive awardees from Headquarters are: David Bates, Walker Lee Evey, Oceola Hall, Lee Barton Holcomb, Harriett Jenkins, Michael Mann, Leonard Nicholson, Richard Powell, and Louis Williams; from Ames: Marcelline Smith and Milton Thompson; from Goddard: Stephen Holt and Vincent Salomonson; from Johnson: John Aaron, Eugene Kranz, Elric McHenry, John O'Neill and Harold Stall; from Kennedy: George English, Walter Murphy and James Thomas; from Langley: H. Lee Beach, Darrell Branscome, Lana Couch, John Stokes and Darrel Tenney; from Lewis: Henry Brandhorst, Brent Miller and Joseph Saggio; and from Marshall: Carolyn Griner, Charles Henke, John Lynn and John McCarty.

## Changing Jobs

Astronaut **Mae C. Jemison** left NASA on March 8 to pursue interests in teaching, health care issues and mentoring young people—particularly those who traditionally have been left out of careers in science and technology.

"I leave with the honor of having been the first woman of color in space, and with an appreciation of NASA—the organization that gave me the opportunity to make one of my dreams possible," said Jemison. "The experiences of the NASA astronaut program have opened many doors, and provided a way to put my hard work and training to use for the good of others."

The 36-year old medical doctor was selected for the astronaut program in June 1987. She was a science mission specialist on the STS-47 (Spacelab-J) flight in September 1992, a cooperative mission with the Japanese to study life sciences and materials processing. Jemison was a co-investigator on the bone cell research experiment flown on that mission.

Among the many personnel changes that have occurred in recent months:

**Wesley Huntress** has been appointed Associate Administrator for NASA's new Office of Space Science. He had been acting in that position since October. **Shelby Tilford** was named Acting Associate Administrator for the new Mission to Planet Earth Office, and **Harry Holloway** was named Associate Administrator for the new Office of Life and Microgravity Sciences and Applications. In April, the Office of Exploration was made a part of the Office of Space Science, and **Michael Griffin**, former Associate Administrator for Exploration, was reassigned as the agency's Chief Engineer.•

**A**lthough we haven't yet found a satisfying answer to the question of whether Congress truly understands NASA, we're getting closer.

## The Question

by Dr. John Lawrence,
Office of Legislative Affairs,
NASA Hq.

We call it The Eternal Question or The Universal Question. Sometimes we just call it The Question.

We hear it from scientists, from astronauts, from center directors and from other key NASA figures who visit us inside The Beltway to be near the legislative process. As sure as God intended people to fly, sometime during their visit they drop The Question. The exact wording may differ slightly, but it's usually something along the lines of, "Why can't we make Congress appreciate the important and exciting things the agency does?"

We at NASA take tremendous pride in the unique aspect of our organization. We are unlike anything else in government, or in the private sector, for that matter. Partly because of this uniqueness, no mobilized, vocal constituency exists that is interested in NASA's mission.

Regulatory agencies have such a constituency. Say, for instance, the Interstate Commerce Commission took an action that adversely affected the trucking industry. Or the Federal Communications Commission issued a regulation that affected the broadcast media's First Amendment freedoms. Institutions with enormous financial and political power would react immediately, decisively and loudly. Having no regulatory authority, NASA lacks a comparable constituency.

Nor does the agency produce goods and services that go directly to the public. If the government were to reduce Social Security payments, for example, or cut veterans' benefits, the response would be huge. One can argue that NASA influences technology, the aerospace industry and the general economic welfare — all of which is true. But the effects are less obvious, and taxpayers understandably tend to react to government programs in proportion to their perceived vested interests.

Then there are the emotional issues like abortion, school prayer and gay rights — issues that can polarize and mobilize people in great numbers. Opinion surveys show that while most taxpayers favor a strong space program, space is not an emotional issue.

The final factor, of course, is money. Although it seems ludicrous to say it, NASA's $15 billion budget is among the government's more modest expenditures. The space station costs approximately 1/7th of one percent of the annual budget. So the rise and fall of space spending does not generate the kind of shock wave that comes from, say, the proposed closing of military bases around the country, which has regional impacts of huge significance.

NASA also operates under specific guidelines when approaching the Congress. We can and should educate lawmakers on the President's program and budget for NASA, but certain types of lobbying are prohibited by law. Penalties can be severe, including fines, jail sentences and mandatory removal from federal service. Expressly forbidden activities include:

Use of appropriated funds in an attempt to influence, directly or indirectly, members of Congress in support of or in opposition to proposed legislation.

Use of appropriated funds for publicity or propaganda designed to support or defeat pending legislation.

Attempts to accomplish indirectly what cannot be accomplished directly — for example, by assisting or soliciting private groups or organizations.

We must also be sensitive to NASA's position as an element of the Executive Branch of government. Our charter is to defend the President's budget — all of it, not just NASA's share. If any of us were to disagree with some aspect of the budget, whether it's foreign aid, or defense, or even another part of the NASA budget, it would be inappropriate to advance those personal views while acting in an official capacity.

A remarkable fact is that, despite the limits and conditions that constrain us, NASA enjoys a good deal of success in dealing with the Congress. A quick look at how other segments of government fare in discretionary funding shows that NASA does comparatively well. That could be why our answer to The Question may sometimes seem lacking — because to a great extent, Congress does understand and appreciate the important and exciting things that NASA does. •

**During working hours, Bob Sieck oversees Space Shuttle launches at the Kennedy Space Center. On weekends, though, you might find him behind the wheel of a race car, doing about 120 mph.**

## Sunday Driver

by Mitch Varnes, KSC

Standing in the firing room at the Kennedy Space Center Launch Control Center, Space Shuttle launch director Bob Sieck is the epitome of cool under pressure. A senior manager with the technical know-how that comes from a lifetime of hands-on engineering, you wouldn't think the 54-year-old Sieck would need more excitement in his life. But when he's not sending Shuttles into space, he has another favorite passion — racing cars.

Sieck joined NASA in 1964 as a systems engineer for the Gemini program. His experience with car racing dates back even further, to high school weekends when he used to drive a 1946 Oldsmobile convertible over to the local track to watch the drivers speed around the course.

Sieck still frequently spends his weekends at the racetrack, but he no longer drives an old car and he no longer sits in the grandstands. A competitive member of the Sports Car Club of America (SCCA) since 1970, he's likely to be behind the wheel of a Nissan 300 ZX, leading a pack of dozens of other weekend racers.

Typically these outings are at nearby Florida tracks like Daytona, West Palm Beach and Sebring, but Sieck also occasionally travels north to Atlanta, Savannah or Charlotte for bigger events. A five-time SCCA regional champion who competed in Formula-type cars before moving to his current class, Sieck sees car racing as an outlet from the daily pressures of preparing and launching Space Shuttles.

"It's an escape," Sieck says of his hobby. "There's nothing else on my mind when I'm working on my car or racing it. It doesn't matter whether you're going 120 mph on a straightaway or 30 mph on a curve, there's no place for daydreaming on the track because you're concentrating on the moment and constantly strategizing your plan."

Although he sometimes competes in three-hour endurance events, most of Sieck's races average under an hour.

"The short races are good because you can usually run straight through them without having to worry about making a pitstop," he says. "If you pit in these short races, you're pretty much out of the running anyway."

Even without the pitstops, a racer needs a crew, and Sieck usually has no trouble finding experienced help. NASA engineer Tim Potter, former KSC Director Forrest McCartney and Space Shuttle Director and former astronaut Brewster Shaw are among those who have taken wrenches to Sieck's car.

"Bob races a car in much the same way that he launches Space Shuttles," notes Shaw. "He's focused, and he doesn't let emotions get in the way of the task at hand. But beneath that brittle exterior there's an extremely competitive heart."

Other supporters of Sieck's high-speed hobby are his wife, Nancy, and his son, Bruce, who lately has taken to racing his own car on weekends.

"I can't really say I've enjoyed going to the track all these years," admits Nancy. "But it's been a great escape for Bob, and a good place to take the kids. Now racing is something he can share with our son. They speak the same language."

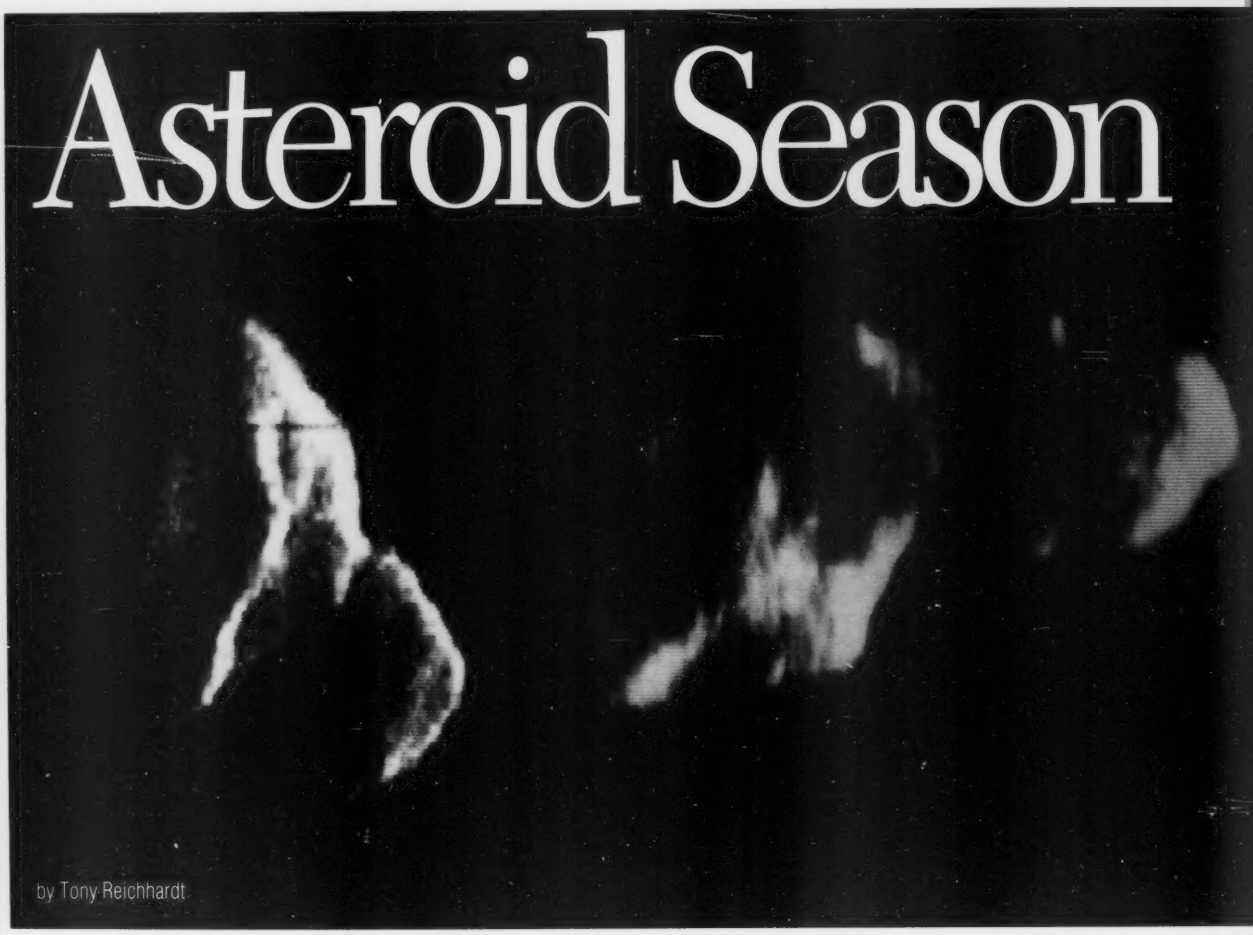
Even though both of his passions are demanding, Sieck contends that he hasn't gotten tired of either the rocket ranch or the race track.

"I'm still as excited as I've ever been," he says. "Racing cars and launching Space Shuttles are actually pretty similar efforts. You spend a lot of time getting ready and making sure everything is as good as it can be, and then it's over in minutes.

"A successful launch and a good racing finish are very rewarding," he adds, "but I'm always looking forward to the next one." •

*Mitch Varnes is a public affairs officer at the Kennedy Space Center. He wrote about plant research in the Winter 1993 issue of the magazine.*

# Asteroid Season



by Tony Reichhardt

As recently as two years ago, if you wanted to show someone what an asteroid looked like, you had to cheat. You could show them an artist's conception, or a chunk of meteorite, or a blurred streak on a photographic plate, or — the most common lie of all — a picture of the Martian moon Phobos, which scientists believe is a captured asteroid. But when it came to the real thing, there wasn't a real thing to show.

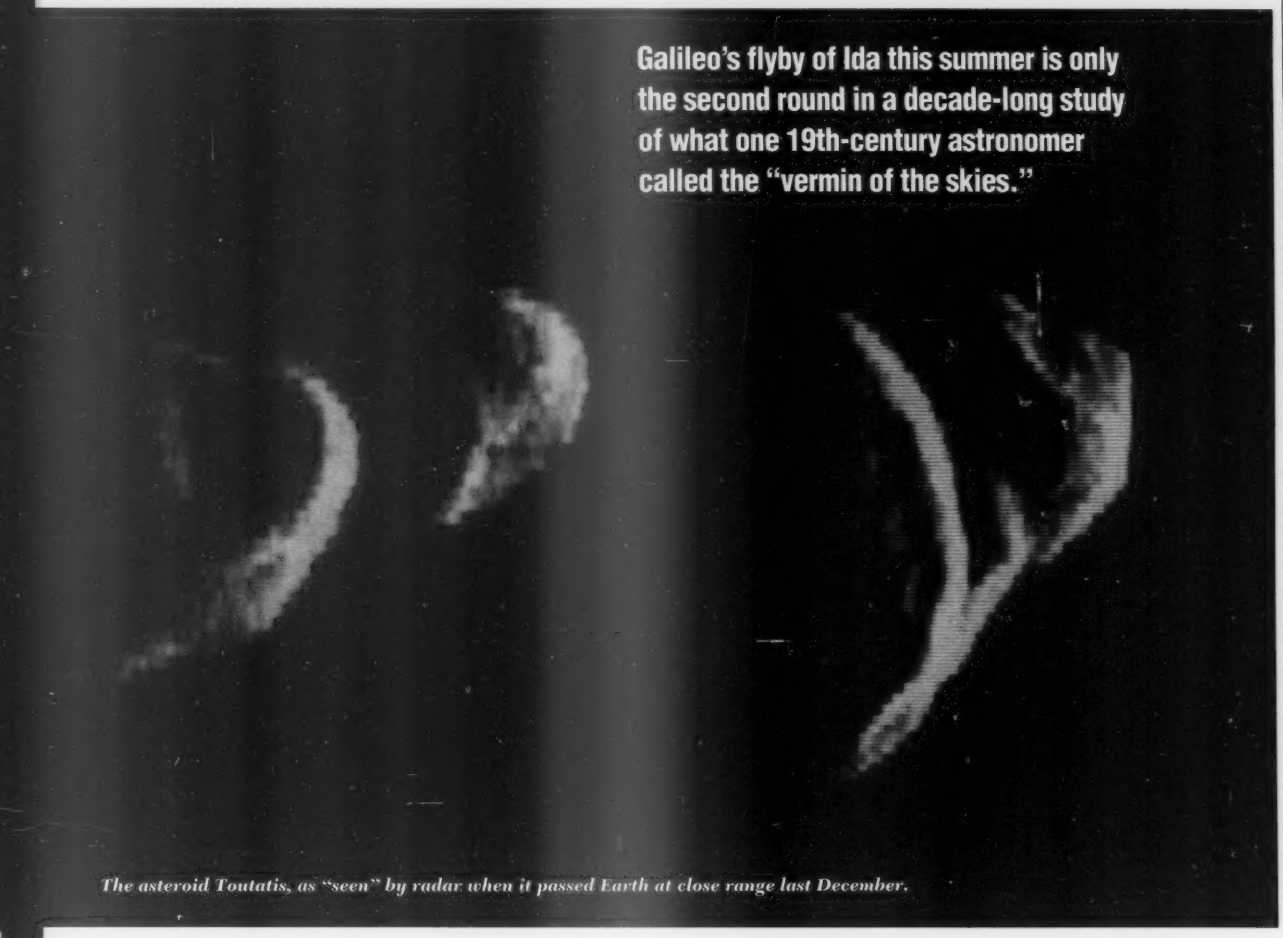
*951 Gaspra, the first asteroid visited by spacecraft.*

Now, thanks to the Galileo spacecraft, we know what at least one asteroid looks like. In October 1991, as it dipped inside the broad belt between the orbits of Mars and Jupiter where most of these objects reside, Galileo snapped the first close-up pictures of an unassuming rock by the name of 951 Gaspra. It was the opening act in what is shaping up to be the decade of the asteroid, with at least three more spacecraft encounters planned between now and 1998.

Asteroids are the crumbs left over from the formation of the Solar System, the stuff that never quite made it to become a planet. They aren't particularly glamorous, but they've managed to stir up a great deal of interest among scientists, who see them as clues to the formation of the Solar System, among space futurists, who see in them millions of dollars worth of metals and other resources, and among the public, which has become fascinated by the idea of an asteroidal apocalypse.

After years of speculating about these orbiting hunks of rock, which one 19th century astronomer dismissed as the "vermin of the skies," we're finally starting to explore them. As Galileo continues on its

**Galileo's flyby of Ida this summer is only the second round in a decade-long study of what one 19th-century astronomer called the "vermin of the skies."**



*The asteroid Toutatis, as "seen" by radar when it passed Earth at close range last December.*

scenic route to Jupiter (*NASA Magazine*, Fall 1992), it will zip past its second asteroid, Ida, on Aug. 28. Although the flyby distance will be greater than at Gaspra (2,400 vs. 1,600 kilometers) the pictures of Ida will be twice as detailed. This is partly because Ida is much larger than Gaspra (44 vs. 19 kilometers long), and partly because Galileo will be taking pictures as late as four minutes before the closest approach, vs. only nine minutes at Gaspra, because mission planners now have greater confidence that the cameras can catch the tiny, speeding asteroid in their field of view.

The pictures of Ida should show an object similar to Gaspra: an irregular, pockmarked rock, fractured in places where it broke off from a larger "parent body" some hundreds of millions of years ago. But Ida orbits in a region of the asteroid belt where collision rates might be higher, so it may be a younger fragment, with fewer small craters on its surface.

Scientists also will be examining Galileo's spectral data, which can help determine the mineral composition at the surface of the asteroid. The spacecraft won't come close enough to be affected in any significant way by Ida's gravity — too dangerous — so scientists won't get an estimate of the asteroid's mass. But they may see the same curious hint of magnetism that Galileo detected at Gaspra, which could be due to magnetized bits of metal embedded in the rock rather than a true magnetic field.

The scientific return from Ida promises to be richer than that from Gaspra, but the news will take longer to get here. Because Galileo's main radio antenna is stuck in a half-open position, mission managers are forced to rely on a backup antenna that can only transmit data at a maximum rate of 1,000 bits per second—slower than most desktop computer modems. Even that rate won't be available until the spacecraft's Jupiter mission begins in 1995, however. In the meantime,

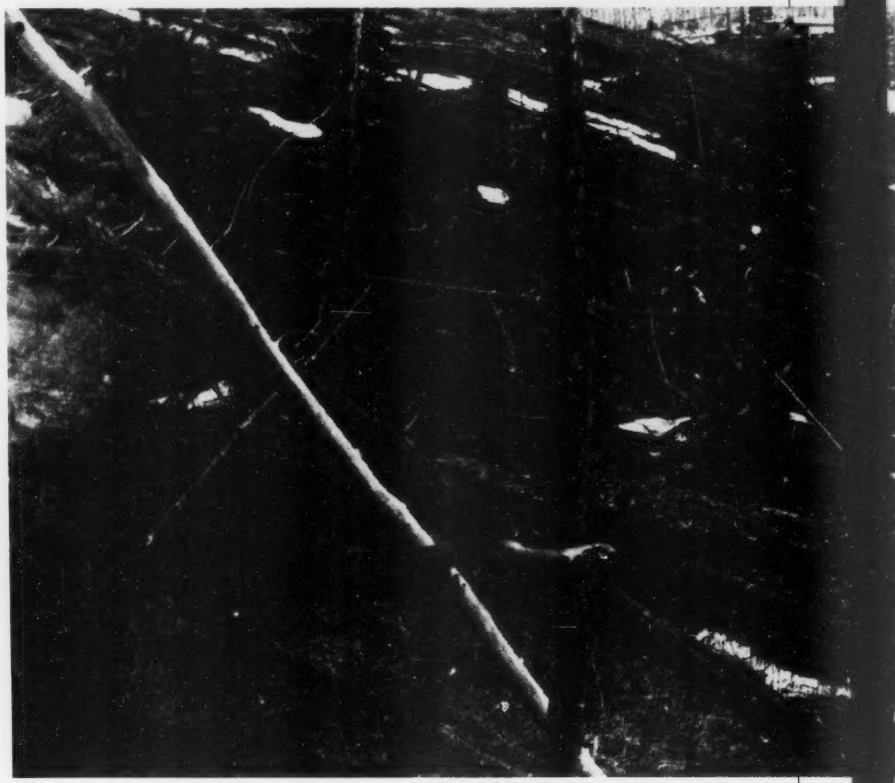
scientists will receive images and other data recorded during the Ida flyby at the paltry rate of 10 to 40 bits per second.

Joseph Veverka of Cornell University, a member of the Galileo imaging team, says the best pictures should be relayed within a week of the encounter. After that, though, the team will have to wait patiently for the information to be played back from the onboard tape recorder over the year and a half following the Ida flyby. Due to budgetary and logistical constraints, they may not even be able to play back the entire contents of the tape recorder before Galileo gets to Jupiter. But Veverka says the team will be able to prioritize and retrieve the choicest data from Ida.

Although Galileo scientists are understandably disappointed at the loss of the high data transmission rate, they still believe the overall mission can achieve more than 70 percent of its scientific objectives. And, says Veverka, "Drinking three-quarters of a glass is better than drinking nothing."

Gaspra and Ida are both residents of the Main Belt, but this is by no means the only place to find asteroids. Theorists believe that collisions between asteroids can knock some of the resulting fragments into orbits that approach, or even cross, the orbit of Earth. About 250 such objects have been discovered to date.

NASA is currently making plans to explore one of these asteroids in detail in the mid-1990s. The so-called Near Earth Asteroid Rendezvous, or NEAR, spacecraft could be launched as early as 1996 if funding begins in the next fiscal year. One of the agency's proposed Discovery Solar System missions, NEAR is being designed at the Johns Hopkins University's Applied Physics Laboratory. Given a launch in February 1996, it would rendezvous with the asteroid Eros on Christmas Eve, 1998, then stay in orbit around it for approximately a year, studying its surface, composition and surroundings.



*June 30, 1908: An asteroid impact leveled 2,000 square kilometers of Siberian forest.*

NEAR is something scientists have wanted for a long time—a thorough, continuous investigation of an asteroid over a period of many months. About the same size as Ida, Eros is one of the largest near-Earth asteroids. It also is well known, having been discovered in 1898.

That makes it an ideal target, according to Stamatios Krimigis, head of the space department at the Applied Physics Laboratory.

"If the community had to pick one asteroid that would be the most scientifically interesting [for a rendezvous], it would be Eros," he says.

But NEAR won't be the first spacecraft to visit a near-Earth asteroid. That honor goes to a mission called Clementine, sponsored by the Pentagon's Strategic Defense Initiative (SDI) office and planned for launch next January. This unique project is actually a test of advanced spacecraft technology—batteries, solar arrays, sensors and the like — developed for the SDI program. But rather than test their new hardware in boring old Earth orbit, mission managers opted to send Clementine into orbit around the Moon, then on to a quick flyby encounter with the asteroid Geographos on Aug. 31, 1994. As it passes the asteroid, Clementine will

Photo courtesy of Smithsonian Institution

study it in infrared, visible and ultraviolet light. A NASA science team led by Eugene Shoemaker of the U.S. Geological Survey, who also runs a ground-based search for new asteroids, is handling science data analysis for the mission.

Clementine will get an assist from observers on the ground, who plan to "image" Geographos with radar as it nears the Earth to help pin down its exact orbit. Steven Ostro of the Jet Propulsion Laboratory collected the first such images of a near-Earth asteroid four years ago. By bouncing radar waves off a passing rock called 1989 PB and interpreting the echoes, he was able to get a rough idea of the object's shape.

Last December, Ostro took his radar imaging technique a step further when a small asteroid called Toutatis passed within 3.6 million kilometers of Earth. Using the large antenna at Goldstone, Calif., he was able to determine the asteroid's diameter (6.5 kilometers), shape and even its rotation rate (once every 10 or 11 days).

"The images are so good I feel silly having talked about the 1989 PB results as 'images'," says Ostro.

Most curious of all was the object's shape. Like 1989 PB (which has since been renamed Castalia), Toutatis is what asteroid-watchers call a "contact binary," formed when a pair of asteroids collides and welds together like two lumps of Play-Doh. These have to be very low-speed collisions, however, says Ostro. Any faster, and the original objects would smash each other to bits.

Before they collided, the two pieces of Toutatis were probably bound together gravitationally as a kind of binary asteroid system. Scientists have found matching pairs of craters on the Moon, suggesting that two objects made their fatal impact at once. The same kinds of pairs must exist fairly commonly in the asteroid belt, some of which eventually merge to become single, bifurcated objects like Toutatis.

In fact, says Ostro, "If you look at the 30 or so Earthcrossers that we've detected with radar, for about 20 percent of them, we have a signature that implies some kind of a strong bifurcation."

Ostro thinks as many as 10 percent of the total population of Earth-crossing asteroids could be contact binaries. He hopes that by the end of the 1990s, observers will be able to spot a gravitationally bound pair before they weld together. At this point, though, scientists have only just started to catalog the varieties of Earth-crossing asteroids, based on a handful of samples.

"There's a whole zoo of possibilities we have yet to see," says Ostro.

Of course, there's more than an academic interest to all this asteroid-hunting. The warning is a familiar one, but it bears repeating:

*These things can be deadly!*

At the northern tip of the Yucatan peninsula in Mexico, not far from the modern-day resorts of Cancun and Cozumel, is a small village called Chicxulub. Pronounced *chick-choo-loob*, it means "the Devil's tail" in Mayan. Appropriate, considering that many scientists now believe Chicxulub to be the site of one of the biggest catastrophes in Earth's history.

Sixty-five million years ago, or so the thinking goes, a 10 kilometer-wide asteroid hit the Earth, throwing enough material into the atmosphere to obscure the Sun for months, which led to the demise of the dinosaurs and many other species. Ever since this asteroid-extinction theory was first proposed in 1980, scientists have been looking for evidence of the crater that must have been caused by such a large impact. Although the search had closed in on the Caribbean region, no one had turned up a "smoking gun" until very recently.

In 1989, Adriana Ocampo of the Jet Propulsion Laboratory attended a conference where she saw Landsat pictures of the Yucatan that Charles Duller of the Ames Research Center and his colleague Kevin Pope of Geo Eco Arc Research had been using for hydrogeological and archaeological studies. Ocampo, who had been doing her own research on impact craters, was immediately impressed with the ring-like features that

Duller and Pope had found.

"When I looked at the data, I saw that the signatures were right there — the magnetics, the gravity, everything was pointing at what typically you'd see as the signature for impact cratering," she says.

Although geologists working for a Mexican oil company had first suggested that the 180- to 240-kilometer-wide Chicxulub structure —it barely resembles a crater any more—was the surface evidence of an asteroid impact, it wasn't until Pope, Ocampo, and Duller published their results in 1991 that scientists began focusing on Chicxulub as the site of The Impact.

Two years later, the evidence is still mounting. The rocks underlying the crater remnant have been dated at almost exactly 65 million years, and geologists have found iridium, which appears in higher-than-normal amounts both in meteorites and in terrestrial rocks of this age (it was this global iridium layer, in fact, that led to the asteroid-extinction theory). Ocampo says a next step will be to search for flood deposits caused by enormous tidal waves as well as other indirect evidence of the impact. Since the asteroid hit in what was then a shallow sea, the searchers will concentrate on the Maya Mountains in nearby Belize, which were above water at the time.

Ocampo and her colleagues also are beginning to model what would have been the biospheric effects of such an impact. Their preliminary results suggest that a 10-kilometer asteroid would have thrown something like a *trillion* metric tons of sulfur into the atmosphere. That would have been enough, she says, to cause "total darkness" for six months, halting photosynthesis and sending many species, particularly large animals like the dinosaurs, to their eternal reward.

The asteroid-extinction theory remains controversial, but it is becoming more accepted. And many researchers are starting to believe that it has happened more than once. Verne Oberbeck of the Ames Research Center is among those who suspect that asteroid impacts played a role in the rise and fall of life — several times — on the early Earth. He also finds evidence

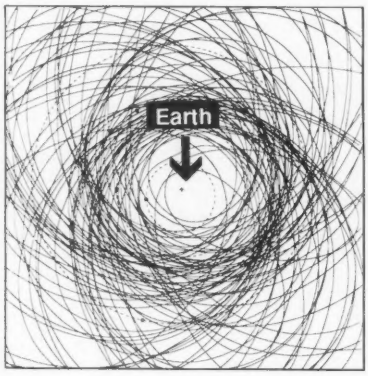



Photo courtesy of Richard Binzel

***The Swarm: Orbital tracks of the 100 largest known near-Earth asteroids.***

that impacts helped to trigger the breakup of the large supercontinent of Gondwanaland, which split up more than 200 million years ago to form present-day Africa, Australia, India, South America and Antarctica.

Asteroids don't have to be so literally Earth-shattering. They can wreak local havoc as well. The well-documented explosion in 1908 over Tunguska, Siberia, that flattened 2,000 square kilometers of forest with the force of a 12-megaton bomb recently has been attributed to—no surprise—a stony asteroid about 30 meters in diameter. Another, smaller object struck Siberia in 1947. Not to mention all the near misses, like the truck-sized object that came closer than the Moon in 1991.

It's starting to dawn on us that we're getting rained on.

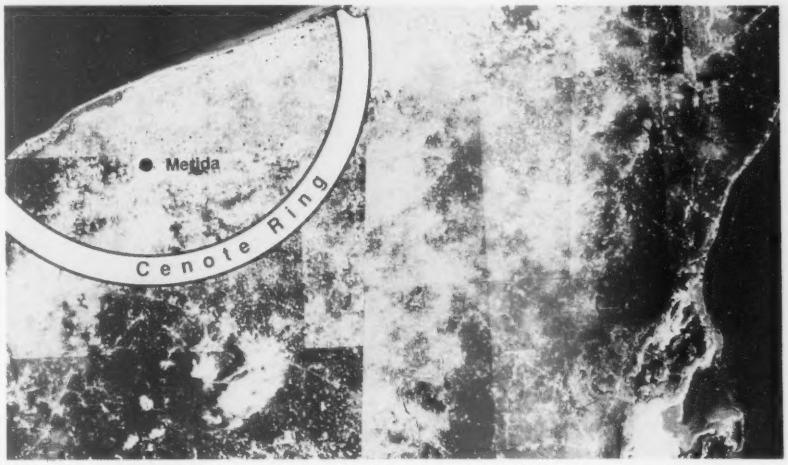
The threat of impact with Earth has in fact added new urgency to the handful of asteroid searches now going on around the world, and has led to calls for a more comprehensive catalog of what's out there. The first Earth-crossing asteroid, Apollo, wasn't even identified until 1932. Today Eleanor Helin of the Jet Propulsion Laboratory leads a handful of observers, mostly funded by NASA, who are slowly but steadily adding to the inventory.

Helin has spent the past 20 years photographing the skies, primarily from California's Palomar Mountain, hoping to see the tell-tale streaks of moving asteroids. Her group finds anywhere from 12 to 14 new near-Earth asteroids "and a couple of comets" a year, accounting for about half the discoveries worldwide.

Helin is planning to upgrade to a more efficient search method using electronic charge-coupled-device (CCD) detectors which already are being used in an asteroid search program at the University of Arizona. NASA, the Department of Defense and the Department of Energy are working out an agreement to use CCD-based cameras developed by the Lawrence Livermore National Laboratory at military space surveillance stations in Hawaii, New Mexico and other locations.

Ultimately, say many scientists, this kind of electronic detection—where computers do the work of spotting moving objects against the background of millions of stars—is the way to go if you're serious about surveying asteroids.

At the direction of Congress, NASA convened two workshops last year to look at the threat from




*The remnant of a 65 million year-old crater in the Yucatan peninsula appears today as a semicircle of sinkholes, or cenotes.*

incoming asteroids and possible responses to that threat. The NASA International Near-Earth-Object Detection Workshop recommended a long-term (20 year), worldwide observing strategy using six different telescopes outfitted with electronic detectors. The survey would be known as "Spaceguard," after the asteroid watch established by the citizens of Earth—*after* they'd already suffered one catastrophic impact—in Arthur C. Clarke's futuristic novel *Rendezvous With Rama*. Although Spaceguard is not yet part of any official plan, NASA's Solar System Exploration Division is currently funding work on precursor detection and analysis technology.

David Morrison of the Ames Research Center, who chaired the detection workshop, says that "it would have been impossible to think of doing a [comprehensive] survey 10 or even five years ago with the old-fashioned technique of taking photographs and looking at them. This system would discover one new asteroid—or some other moving thing—every few seconds."

In 20 years, says Morrison, the Spaceguard system could conduct a fairly complete inventory of all objects larger than one kilometer out to a distance of about 200 million kilometers. That advance warning would give us time to divert or destroy any threatening object with a nuclear explosion or by some other means.

Determining the risk from asteroids is an uncertain business. Clearly, large impacts do not happen very often. But because their consequences are so dire, the statistical risk of dying due to an asteroid impact actually compares to that of other natural disasters like hurricanes and earthquakes.

"This is an extreme case of the very infrequent but truly catastrophic kind of event," says Morrison. "It happens less frequently than anything else. There's no example in history of anyone being killed by one of these things. But when it happens, a billion people could die."

And some day, maybe next Thursday, maybe 300,000 years from now, it definitely will happen. But right now we have no idea where the asteroids are located, says Morrison, so "it's just as likely to happen next year as any other year."

In fact, scientists have identified only about 100 Earth-crossing asteroids larger than one kilometer, out of an estimated population of 2,000.

"We're safe from those 5 percent," says Morrison. "But what about the other 95 percent? We've never found them."

And that's only the kilometer-sized objects. Helin, who doesn't like to over-hype the impact threat, admits nonetheless that the 50-meter object that blasted out Meteor Crater in Arizona 50,000 years ago (which, by the way, wasn't even recognized as an impact scar until this century) would be an unparalleled disaster if it struck a populated area today.

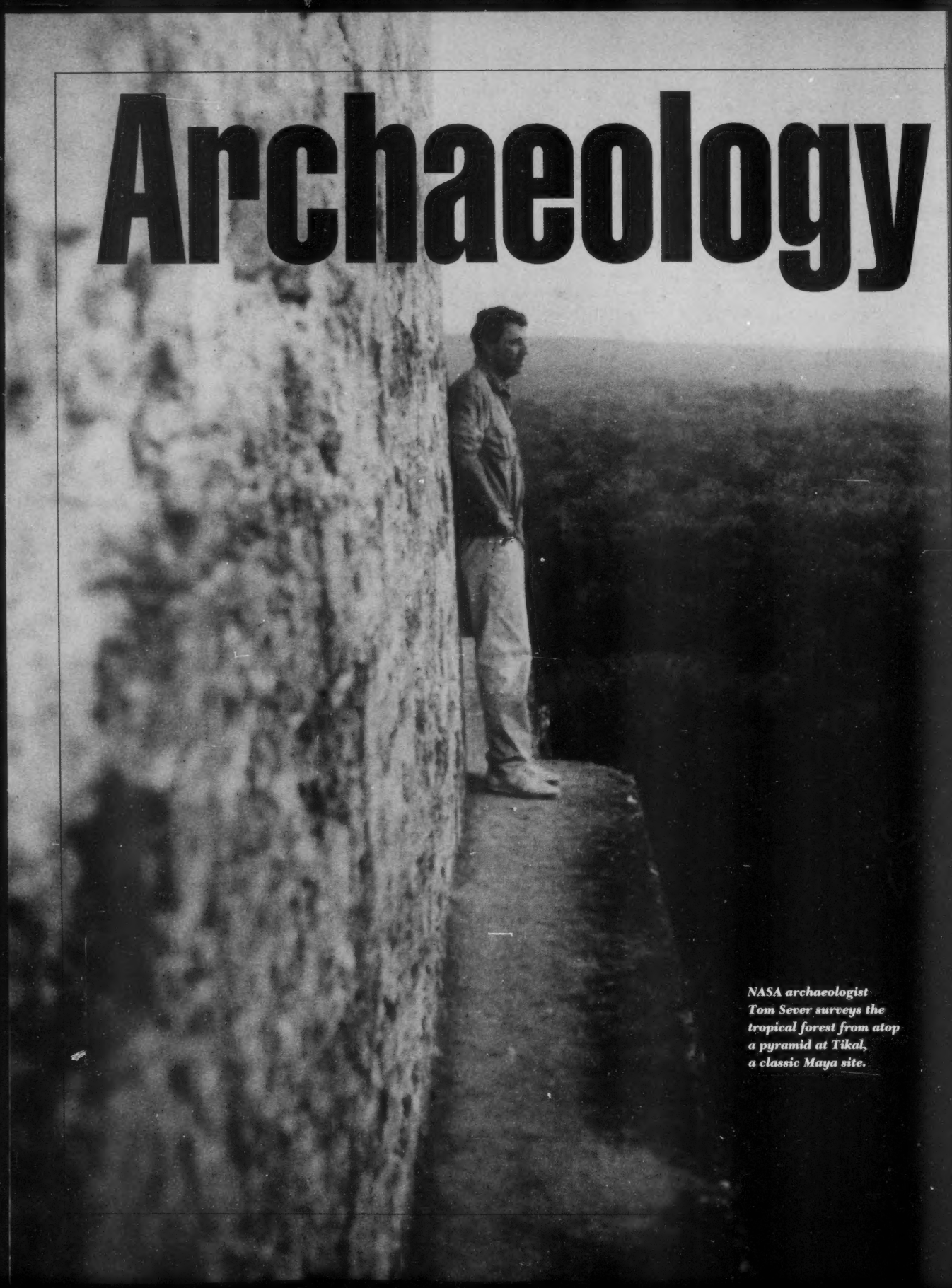
"If you drop even that small an object down into one of our cities," she says, "it's a holocaust."

It's easy to make a case, and environmentalists do all the time, that we humans aren't much good when it comes to taking care of Mother Earth. So far, for all our exalted position at the pinnacle of evolution, we've managed to wipe out thousands of other species, load the atmosphere with greenhouse gases and rip big holes in the ozone layer.

But maybe Spaceguard is the achievement that would finally redeem our species — the only creatures who've ever mustered enough intelligence to recognize the Great Cosmic Threat and actually contemplate doing something about it. It would be the ultimate act of environmental protection. Perhaps humans might have some use after all. •

*Tony Reichhardt is a freelance writer in Washington, D.C.*

# Archaeology



*NASA archaeologist Tom Sever surveys the tropical forest from atop a pyramid at Tikal, a classic Maya site.*

by Susan Huseonica

# From Above

*The hike through the harsh jungle of northern Guatemala's Peten region had been long and arduous, at times even dangerous. Now, at El Mirador, the prehistoric Mayan temples seemed to spring out from under the thick forest canopy and touch the sky. Tom Sever climbed the steep staircase of the 51-meter-high Danta temple, the largest in the Peten, and scaled its limestone walls. With labored breath, he eased his way carefully onto the narrow ledge. The magnitude and splendor of the lush rain forest stretched out before him. Could there be a more beautiful sight on Earth, he wondered.*

*As an archaeologist and anthropologist, Sever was even more interested in the people who had built the temple. How had they gotten here? Where were the paths leading from the temple to the now vanished Mayan cities that had been here more than a thousand years ago?*

*As Sever scanned the countryside, he saw no sign of the ancient roadways in the dense forest. He knew they were there, though. He had already seen them—in pictures taken from above.*

For all its fascination, archaeology is a painstakingly slow science. It can take months, years or even decades to excavate an important site—that is, if scientists ever find it at all. But in recent years, archaeologists have found a shortcut: using NASA remote sensing instruments mounted on satellites, the Space Shuttle, airplanes and even trucks to locate traces of lost civilizations.

In the mid-1970s, an ambitious graduate student named Tom Sever was working in the Andes Mountains near Cuzco, Peru, studying and mapping a calendar system used by the Incas. The Inca system, very close to the calendar we use today, consisted of 41 lines radiating from the Temple of Gold. Along each line were eight shrines. When archaeologists multiplied the number of lines by the number of shrines, the total came to 328, which may have been the number of days in the Inca lunar cycle. Sever and others searched daily for the lines and the shrines.

**Tom Sever, NASA's one and only archaeologist, is just as handy with satellite images as he is with a trowel and shovel.**

"After more than two months, we had only walked three of the lines," he recalls. "At this pace, I knew we were never going to know the answers."

Then he had an idea. He remembered reading how NASA's National Space Technology Laboratories in Mississippi—now the Stennis Space Center—had used remote sensing for agricultural, water and soil studies. He wondered if that same technology could be used in his own field of archaeology.

"What happened next was really a turning point in my life," says Sever. He visited Mississippi and was hired by NASA in 1978. Today he remains the space agency's only archaeologist.

Realizing the usefulness of remote sensing to archaeology was one thing, but it had to be put to the test. In 1982, with modest funding, Sever headed off to Chaco Canyon in northwest New Mexico, which has the largest concentration of prehistoric ruins in North America. The Anasazi culture are believed to have used the site as a center for social and religious ceremonies from 950 to 1,100 A.D. The area already had been studied extensively, both on the ground and in aerial photographs. But Sever believed that he could uncover new features in pictures taken by remote sensing instruments.

First he acquired images from the Thematic Mapper Simulator (TMS) instrument flown on a NASA Learjet. The TMS recorded data in seven bands of the electromagnetic spectrum, from visible wavelengths to the thermal infrared. Next, the Thermal Infrared Multispectral Scanner, or TIMS, was flown over the area on its first archaeological field test. The TIMS can detect temperature differences as slight as one-tenth of a degree Celsius on or near the ground surface.

A soil's composition is one factor that affects its temperature. Buried stone can cause the soil to retain or lose heat at a different rate than surrounding soils. Similarly, dirt-filled irrigation ditches hold more moisture and give off less heat than nearby soils. These temperature differences make it easy for the TIMS to "see" the buried stone or ditches.

*A pyramid at Tikal.*

After Sever acquired his remote sensing data on Chaco Canyon, he fed them into a computer for processing and took the computer-enhanced images into the field for verification.

"Standing in the middle of Chaco Canyon, I could not see anything out of the ordinary," Sever says. "But the computer images told a different story. What stood before me was a well-defined system of roads, one of the oldest in North America."

The TIMS once again proved its value to archaeology when it surveyed a site in Poverty Point, La., dating back to around 1,200 B.C. The site, which was abandoned 600 years later, has a central plaza surrounded by six concentric ridges. When archaeologists combined data they had already collected with information from the TIMS, they saw a previously undiscovered linear feature emanating from the central plaza.

"We dug a trench and discovered that the linear feature was, in fact, a causeway or rampway coming into the site," says Sever. Archaeologists had previously found copper from Michigan and flint from Ohio and Tennessee, which pointed to the existence of a large trade network in the area around Poverty Point.

The most dramatic proof of remote sensing's value to archaeology, however, has been in Central America. Between 3,000 B.C. and 1,500 A.D., an Indian civilization thrived at the base of the 1,600-meter Arenal Volcano in northwestern Costa Rica. This culture predated and outlasted the Mayas and the Aztecs, finally diminishing around the time of the Spanish Conquest. What makes the Arenal site unique, Sever explains, is that the volcano erupted 10 times in 4,000 years, preserving the inhabitants and their villages in 10 successive layers of volcanic ash.

With support from NASA, a cooperative research agreement was established in the mid-1980s to prove the value of remote sensing to some of the nation's leading archaeologists. Sever teamed up with Payson Sheets of the University of Colorado, the National Science Foundation and the National Geographic Society to see if space technology could help uncover

secrets about the prehistoric Indian culture in Costa Rica.

Sheets led a team of scientists into the region for an initial survey, which was followed by overflights of NASA-developed remote sensors. By mid-1985, a large remote sensing database had been compiled from infrared photography and TIMS thermal data. Added to this were Landsat data and information recorded by radar and LIDAR (light detection and ranging) sensors. The radar revealed linear and geometric features on the ground, while the LIDAR's laser beams bounced off the tops of vegetation and ground features. If the LIDAR passed over, say, an eroded footpath, the path's indentation would show up in the data.

How did all this help the archaeologists?

"In Costa Rica, we know that man will make the most of his environment," Sever explains. "He will only live in certain areas, near fresh water. Most of the food he intends to grow can only be done at certain elevations. From this, we can isolate on the computer specific spots that meet the criteria and investigate those areas."

Another technique is to ask the computer what all the known archaeological sites have in common.

"Then we can produce a map that shows other areas with the same characteristics and inspect those areas," he says.

Working out of a wooden shack they rented for less than a dollar a day in the heart of the Costa Rican forest, Sever and Sheets carefully studied the infrared photographs of the region. Sever spotted thin lines, possibly roads, running across one of the pictures. They turned out to be the thermal outlines of prehistoric footpaths—the oldest known in the world—buried under volcanic ash up to one and a half meters deep.

But the infrared photographs were useful only in open pastures. For heavily forested areas, Sever had to rely on the TIMS. The buried footpaths had affected how the soil lying on top of them eroded. This, in turn, changed the soil content and moisture, and therefore the vegetation. Because of this, the amount of infrared light given off by plants growing over the paths was different from that of surrounding plants.

*Tom Sever with a Guatemalan farmer.*

"The sensors were powerful enough to pick up that slight difference," says Sever.

Based on the infrared pictures, three networks of footpaths were uncovered, all leading to a cemetery Sheets had discovered years before. These footpaths, more than half a meter wide, connected villages and other sites that had never been recorded.

Sheets and other archaeologists became believers, but many remained skeptical.

"There was a lot of speculation and criticism that arose from the archaeological and anthropological community," Sever says.

But he continued to spread the word, pointing out the virtues of remote sensing for archaeological investigations. For one thing, he says, it is non-destructive.

"Once a site is excavated, it can never be returned to its natural state. If you happen to dig in the wrong place, you can never recapture the clues you might have lost."

Another factor is the speed that remote sensing offers in identifying promising sites for digs.

"Time is such a critical component in archaeology," he says. "Deforestation and development are destroying archaeological sites faster than they can be recorded."

According to Sever, remote sensing technology already has proved to be a time-saving, low-cost way of prioritizing and pinpointing sites for excavation. It is now being used by scientists around the globe to study civilizations in Africa, Venezuela and throughout Europe.

"But it was NASA that first believed in the technology and supported my efforts," Sever says.

His latest project has taken him into the Central American rain forest where the Mayas lived before vanishing completely around 900 A.D. The field work is necessary to verify remote sensing data and to accurately map the archaeological sites throughout the region. But Sever's idea of a "field trip" is exhausting and sometimes dangerous work.

In the field he determines the precise location of archaeological sites using Global Positioning System (GPS) satellites. The trouble is, GPS readings can only be taken when the satellite passes overhead. If that

means climbing to the top of a temple in the middle of the night, when snakes and scorpions are out in force, then so be it.

"I remember one time Dan Lee, who works for Sverdrup Technology at Stennis, climbed up a temple to take a GPS reading only to find the top covered by trees," recounts Sever. Lee kept climbing, to the top of a tree that looked out over a 90-meter abyss. When he held up the GPS receiver to point it toward the satellite, he saw that his arm was covered with red ants.

"Through all of this, Dan was still able to get a GPS reading," Sever reports.

Besides snakes, scorpions and ants, the jungle holds other dangers—like the time Sever's whole group was captured by a band of leftist guerrillas armed with AK-47s and rifles.

"They held us at gunpoint for about ten hours before letting us go," he says, apparently undaunted by the experience.

The extensive remote sensing database collected so far has been successful in locating Mayan roads, some of which may lead to previously undiscovered sites. The imagery, Sever says, shows signs of what may be well systems in the swamp regions. On the edge of these swamps, the images suggest that there may also be large-scale architecture.

Sever believes that the study of Mayan civilization is one of the most important archaeological projects he has undertaken. Learning how the Mayas lived in the rain forest without destroying it may hold valuable lessons about environmental management for our own society.

"We are trying to find out how the Mayas lived in this delicate environment for hundreds of years, when today a few hundred people are close to obliterating the forest," he says.

Sever and the research team are fighting more than snakes, scorpions and guerrillas. They are racing against the clock as well. This part of Central America, one of the last vestiges of tropical rain forest in the world, is being cut down at a rapid pace. Important archaeological sites are being raided by looters, and there is increasing pressure to increase tourism and develop parts of the forest.

*Tom Sever and scientist Dan Lee descend from a pyramid after gathering a GPS satellite reading.*

Sever says there is still reason for hope, however. Recently the Central American Commission for Environment and Development entered into an agreement with NASA to expand the use of satellite remote sensing data by Central American scientists. The agreement includes the governments of Belize, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama.

"Through this unique partnership...we are giving the Central American commission the tools to successfully manage their own environment," says Sever. "They will have the means to preserve and protect the archaeological and environmental significance of the forest, while at the same time making educated decisions about development, settlement and tourism in the area."

NASA also will be working with Central American scientists as part of the Earth Observation System (EOS) program to better understand the dynamics of global change.

Meanwhile, Sever is looking into other archaeological studies. Maybe he'll search for a lost fort in Illinois or the Wright brothers' 1910 hangar in Ohio. Or he might turn up in Utah searching for roadways similar to those in Chaco Canyon, or at the Bering Strait looking for migration patterns.

"Many people believe archaeologists just dig up ancient artifacts or find lost cities," he says. "This simply is not true. We're examining how civilizations have adapted to their environment through time, how they handled environmental shifts, how and why cultures come and go. By studying the past, we can learn valuable lessons that we can apply today and, hopefully, use for future generations. NASA remote sensing technology has given us the chance to do this like we've never done before." •

*Susan Huseonica is a public affairs specialist at the Stennis Space Center.*

**Pharmaceutical companies may soon be able to produce drugs that can neutralize eye cataracts without surgery, thanks to work being done at the Lewis Research Center.**

## Scoping Out Cataracts

by Linda Ellis, LeRC

Ask anyone who has suffered from eye cataracts: Trying to live a normal life with blurred vision can be annoying at best, debilitating at worst. But help is on the way for thousands of potential cataract sufferers, in the form of technology pioneered by scientists at NASA's Lewis Research Center and the State University of New York. A recently developed diagnostic tool may soon allow doctors to identify cataracts in their formative stages. This may in turn lead pharmaceutical companies to develop drugs that could neutralize a cataract without surgery, according to Rafat Ansari, project scientist at Lewis.

The tool is a small fiber optic probe — about the size of a pencil — that can detect protein crystals suspended in the fluid inside the eye. Doctors suspect that these crystals are what forms the cloudy mass that leads to cataracts.

"Until now," says Ansari, "physicians have not had the technology to tell what is really happening inside the lens [of the eye]."

Ansari, a research professor at Case Western Reserve University who works in the Materials Division at Lewis under a cooperative research agreement, developed the instrument with Harbans Dwadwal of the State University of New York at Stony Brook. A prototype of the device, which uses laser light to detect the protein crystals, is being evaluated in a series of studies with volunteer patients.

A normal eye lens is a jellybean-sized transparent tissue. A cataract is formed when the lens becomes cloudy, hindering the transmission of light to the retina at the back of the eye. Common symptoms of cataracts include blurred or double vision, sensitivity to light and glare, less vivid perception of color and a need to change an eyeglasses prescription frequently. Lens opacity due to cataracts is the leading cause of blindness worldwide.

Although the causes of cataracts are varied, they generally result from some kind of change in the chemical composition of the lens. These changes are attributable to aging (senile cataracts), eye injuries (traumatic cataracts), certain diseases and conditions such as high blood-sugar levels in diabetic patients (secondary cataracts), or heredity and birth defects (congenital cataracts). Senile cataracts, the most common variety, can occur as early as age 40.

With the application of Ansari and Dwadwal's fiber optic probe, physicians' guesswork could be eliminated and new drugs could be manufactured to dissolve or slow down the cataract formation before surgery becomes necessary. An estimated 1.4 million cataract surgeries are performed each year in the United States alone.

The probe is based on dynamic light scattering principles. An optical fiber transmits a low-power laser beam so weak that there is no risk of eye damage. Light scattered from within the eye back to the instrument is then picked up by a second optical fiber. After processing on a laptop computer, the pattern of light for an individual patient can be recorded and kept on file. A change in protein particle size might indicate the onset of a cataract.

Ansari points out that fiber optic probes also can measure the sizes of very small particles suspended in solutions. As a result, the devices may prove to be of value in industrial applications as well as in the field of ophthalmology. •

*Linda Ellis is a public affairs officer at the Lewis Research Center.*

# Ocean View

*Instrumented buoys permit extended, unattended ocean measurements.*

**The TOPEX/ POSEIDON satellite may help usher in a new era of reliable long-term climate prediction.**

by Linda Billings and William Patzert

The Blizzard of '93 will long be remembered by people on the East Coast for its fierce winds and deep snow drifts, while West Coasters will recall how it rained so long and hard that they thought California might slide into the sea. Most of us never saw the bad weather coming. But a U.S.-French satellite launched last August had already provided a few tantalizing hints to scientists interested in long-term climate forecasting.

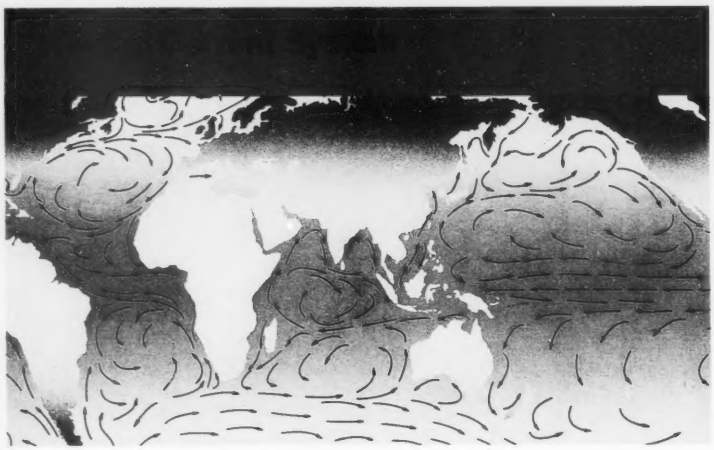
The goal of the TOPEX/POSEIDON ocean topography experiment is not to forecast the weather, at least not in the usual sense. Over its lifetime of three to five years, the satellite—part of NASA's Mission to Planet Earth—will map ocean circulation to better define the role of oceans in short- and long-term climate patterns, including a possible global warming trend.

Oceans are the major reservoir of heat on our planet, and ocean circulation is Earth's primary means of distributing heat around the globe. In that sense, the oceans serve as a kind of thermostat that regulates our weather and climate patterns. Determining how to forecast climate change thus depends on understanding the oceans.

NASA staked out an early interest in weather prediction from space with the launch of TIROS 1 in 1960. The nation's first experimental meteorological satellite, it led to fairly reliable morning and evening forecasts. The U.S. Department of Commerce now runs the national metsat system, but NASA keeps a hand in the business through its research into improved methods of remote sensing.

As most of us have learned all too well from experience with rained-out picnics and freezing Florida vacations, reliable long-term weather prediction is still out of reach. Current forecasts are not accurate beyond five days, although scientists would like to extend the range to weeks, months, or even whole seasons.

TOPEX/POSEIDON will do for climate



*This global pattern of ocean circulation is dominated by gyres that cover an entire ocean basin, circulating clockwise in the Northern Hemisphere, counterclockwise in the Southern Hemisphere.*

forecasting what TIROS 1 did for weather prediction by mapping ocean circulation with unprecedented accuracy. As ocean currents transport heat like slowly moving conveyor belts from equatorial to polar regions, temperature shifts in the upper ocean create the equivalent of peaks and valleys on the sea surface. By precisely measuring these highs and lows, TOPEX/POSEIDON will enable scientists to track with great precision this large-scale ocean circulation, which is both a cause and an indicator of global climate change.

The keys to the mission's success are the satellite's radar altimetry and orbit determination (see page 25), which can measure changes in sea level as slight as 3 centimeters. Circling at an altitude of 1,336 kilometers, TOPEX/POSEIDON is producing a virtually complete map of our oceans, covering 90% of the world's ice-free sea surface every 10 days.

Experiments onboard the satellite, which were developed by 38 investigator teams, focus primarily on ocean circulation and variability. TOPEX/POSEIDON investigations also will delve into geophysics and geodesy (the study of Earth's shape, size, gravity and magnetism) to yield a better understanding of our planet's interior and the motion of its crustal plates. The mission also should result in improved models for ocean tides and currents and the role these tides play in global energy exchange.

**Understanding the world as seen by TOPEX/POSEIDON requires that we learn a new geography of water.**

In many ways, the TOPEX/POSEIDON project is a model of international cooperation. Officially, it's a bilateral partnership between NASA—which provided the primary instruments and a spacecraft bus built by Fairchild—and the French space agency, CNES, which supplied an Ariane launch and an experimental altimeter made by Alcatel Espace. But principal investigators also come from Australia, Germany, Japan, the Netherlands, Norway, South Africa and the United Kingdom. Ground support systems for the mission literally span the globe, with tracking and laser ranging stations in places as far-flung as Easter Island. And the project is linked to other international climate research studies, including the Tropical Ocean and Global Atmosphere initiative and the World Ocean Climate Experiment.

Understanding the world as seen by TOPEX/POSEIDON requires that we learn a new geography of water. We can all point out the Atlantic and Pacific oceans on a map, and maybe can even find the Coral Sea. But where, and what, is the Alaskan Gyre? How about the Antarctic Circumpolar Current?

Gyres are large circulating cells of water that stretch over thousands of kilometers of sea surface. TOPEX/POSEIDON investigators intend to describe the dynamics of these gyres for a large portion of the globe with great accuracy. Scientists also are eager to identify seasonal and annual changes in "conveyor belts" such as the Antarctic Circumpolar Current, which moves more water than any other current in the world and links circulation among the world's ocean basins. They also will study regional ocean dynamics—for example, around the southern tip of Africa, in the Western North Pacific and in the equatorial Atlantic Ocean.

Although the first six months of TOPEX/POSEIDON's life in orbit were devoted mostly to checking out hardware and operations, the spacecraft began producing interesting results almost right away. Scientists looking at data from the satellite saw a possible reason for the weird, wet weather

Americans experienced last winter and early spring. The answer has to do with the El Niño-Southern Oscillation phenomenon, an irregular occurrence caused by a weakening of tropical trade winds that every few years prompts warm South Pacific waters to surge eastward. The interaction of these waters with the atmosphere causes wetter than normal winters in California, along with cold, wet winters in the eastern United States and warm, dry summers in the Southern Hemisphere.

Data from TOPEX/POSEIDON showed that a supposedly fading El Niño event—which first hit the West Coast in the spring of 1992 but was thought to have been abating by winter—was still in force as winter drew to an end. It lingered on, boosted by a huge pulse of warm water that had been traveling across the South Pacific for months. This surge, known as a Kelvin wave pulse, was caused by the interaction of trade winds with surface water in the equatorial western Pacific.

According to investigator Jim Mitchell of the Naval Research Laboratory, TOPEX/POSEIDON provided scientists with their clearest picture yet of a Kelvin wave pulse. Scientists at NRL had predicted the genesis of this particular wave, although it was traveling faster than they had expected. Based on the new data, TOPEX/POSEIDON investigators in late February suggested that there might be at least another month or two of cold, wet weather in store for the continental United States. Their prediction turned out to be all too true.

Although TOPEX/POSEIDON has yet to complete its first year of observations, researchers already are thinking about a successor. Altimetry is the only feasible method of assessing global ocean circulation, and scientists will need at least 20 years of measurements before they understand how this circulation affects climate. A good follow-on mission could be developed for as little as $80 million, compared to $500 million for its predecessor.

*Linda Billings, a senior writer for BDM, is a regular contributor to* NASA Magazine. *Dr. William Patzert, TOPEX program scientist in the Mission to Planet Earth office, collaborated on this article.*

The Mission to Planet Earth has just begun; it will take many years of analyzing the mountains of data returned from space to begin to formulate a definitive picture of what is happening to our climate. At a time of growing global environmental concern, the TOPEX/POSEIDON mission can help governments around the world plan for our collective future. •

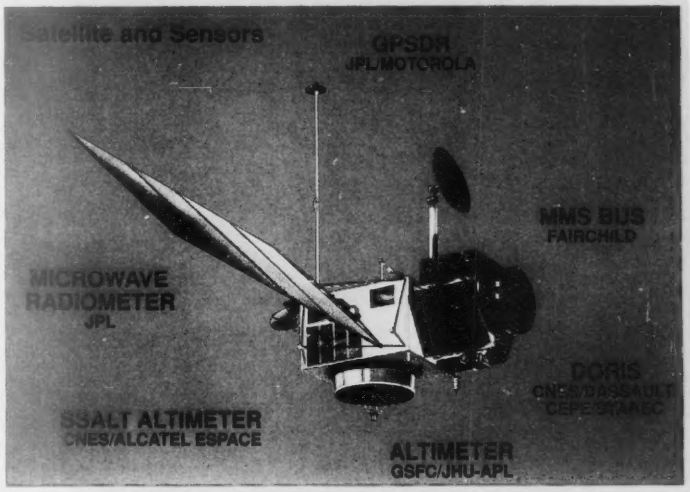
## TOPEX Technology

The study of large-scale ocean currents requires sea level measurements accurate to within a few centimeters over thousands of kilometers of open sea—not an easy task. Until recently, oceanographers had no way to achieve this combination of precision and large scale. But the relatively new technique of radar altimetry fills the bill nicely. In fact, it's the only tool that can produce ocean dynamics data useful to global climate studies.

Radar altimetry works this way: An altimeter bounces microwave signals off the ocean surface, then times their return to the satellite to determine the distance to the water. The satellite's position is determined to an accuracy of 2 centimeters using Global Positioning System satellites, doppler tracking and laser ranging from the ground. All of these data then go to produce global maps of sea surface topography, which, combined with gravitational data, yield a map of dynamic ocean topography, from which ocean current speeds can be calculated.

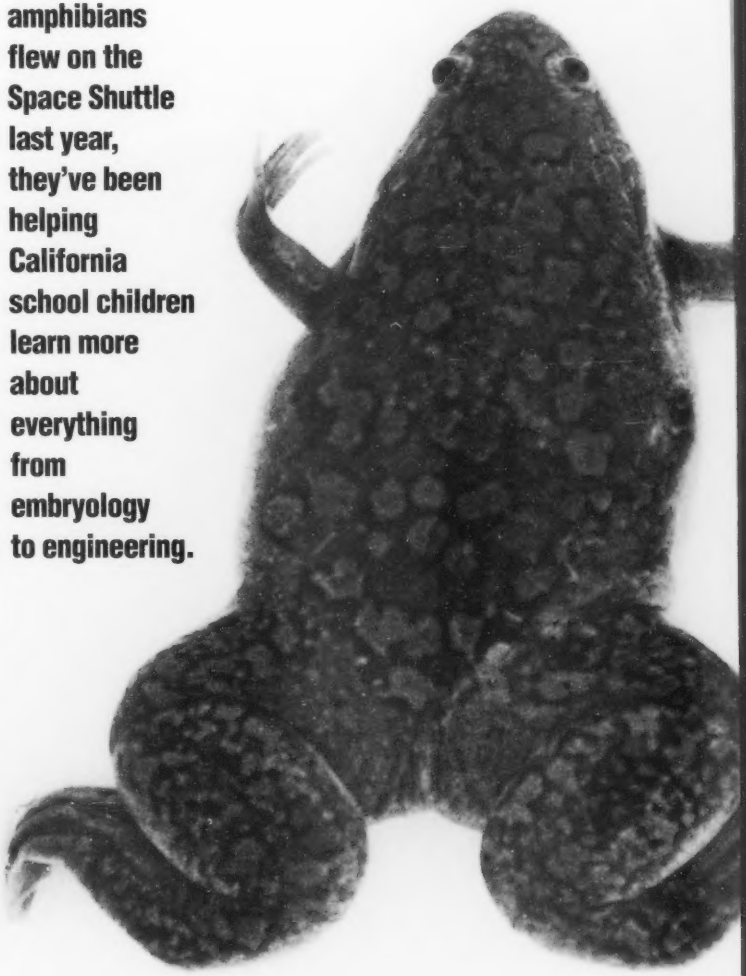
NASA's Dual-Frequency Radar Altimeter (ALT), built by the Johns Hopkins Applied Physics Laboratory, is one of six science instruments onboard the spacecraft. The ALT measures satellite altitude, wind speed and wave height. Another instrument called the TOPEX Microwave Radiometer (TMR), developed at the Jet Propulsion Laboratory, measures atmospheric water vapor, which affects altimeter readings and so has to be factored into ALT measurements to ensure precision. The French space agency, CNES, contributed a second, experimental altimeter as a low-power, low-weight alternative to state-of-the-art technology.

*—Linda Billings and William Patzert*



# When Frogs

**Ever since four hardy amphibians flew on the Space Shuttle last year, they've been helping California school children learn more about everything from embryology to engineering.**



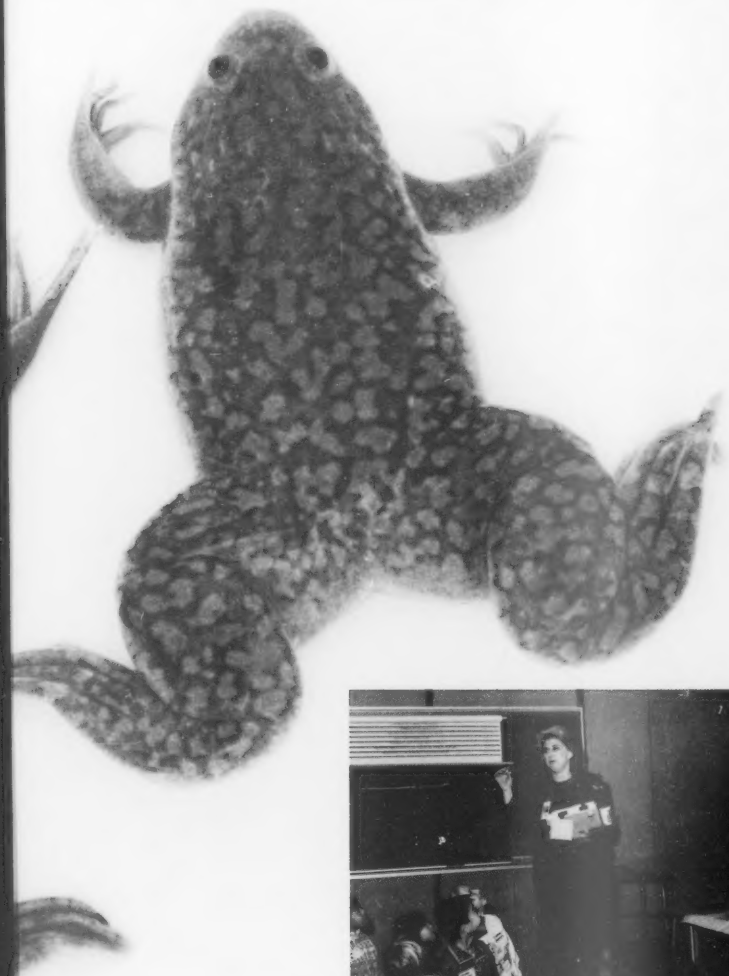
The Silicon Valley, south of San Francisco Bay, is an unlikely place to get kids excited about frogs. High-density buildings and mazes of multi-lane freeways have replaced the once-common orchards, and the only animals you're likely to see are dogs, cats and the occasional squirrel scurrying along a telephone line. Children who grow up here are more likely to recognize a computer chip than a tadpole.

But this doesn't mean frogs aren't popular with city kids. And it doesn't mean adults don't find the green critters fascinating as well.

When four South African clawed frogs flew on last year's U.S./Japanese Spacelab-J mission, newspaper and television reports were full of stories about the country's first "astrofrogs." People all across America watched in fascination as the tiny tadpoles hatched, then tried to swim in the weightlessness of space.

Ken Souza, principal investigator for the frog experiment and chief of the Space Life Sciences Payloads Office at NASA's Ames Research Center, says he was pleased with the public's response.

"The extent to which the media and the public grasped the purpose of the experiment was gratifying," he says. "We weren't just playing with frogs, but actually trying to answer fundamental questions that have stumped biologists for over a century. Even the emperor of Japan asked Japanese payload specialist Mamoru Mohri about the experiment!"



*B.J. Navarro holds an adult frog box like the one that carried the frogs into space.*

# Took Wing

by Jane Hutchison

Although it was a serious scientific investigation, (see page 28) Souza says he wanted to make sure the results didn't get buried in the technical journals. "We felt we had the kind of experiment that could readily excite students of all ages and hopefully stimulate them to pursue science and engineering careers. We also saw the need to help our overworked teachers in bringing science into the classroom."

So after the mission, Souza asked Susan Zapalac, a support scientist at Ames, to develop an education program centered on the frogs. Soon Zapalac, with assistance from B.J. Navarro, who had been stowage manager for the experiment, came up with a creative plan to bring their real-life science project to the classroom. Other Ames employees who had played key roles in the mission volunteered to give one-hour presentations at local schools, one day a month. They included Greg Schmidt, who had been the payload manager at Ames, Sally Ball, the payload scientist, and Cecilia Molesworth and Bob Navarro, who had been responsible for safety, reliability and quality assurance.

Within a couple of months the group was ready to take their show on the road. B.J. Navarro gave her first presentation to the gifted sixth grade class taught by Elizabeth Bliss at Grant Elementary School in San Jose. "I was really nervous," Navarro recalls, particularly since Grant is a magnet school for aviation/aerospace studies.

"When I walked into the office, I saw this big bulletin board covered with photos

*Students listen attentively to details about the STS-47 "astrofrogs."*

and articles about space," she says. Navarro came away impressed with the students' knowledge about the space program and their understanding of its importance.

Her next visit was to Burnett Elementary School in nearby Milpitas, where she spoke to second- and third-grade students. Navarro used a large, colorful poster and a model to explain the intricacies of the Spacelab module and the Space Transportation System. A slide show introduced students to the STS-47 crew and explained the preparation of the Spacelab, the roll-out to the launch pad, crew preparations, launch and landing.

**"The students felt this was news in the making. They were participating in a current program, not just reading about ancient history."**

"Slide shows are usually pretty boring," says Burnett teacher Penny Bronzini. "But this slide program was so well done, the students were ready to jump in."

The discussion then turned to the importance of life sciences research in space. Navarro talked about the pre-flight, in-flight and post-flight phases of the frog experiment, and showed a video of astronauts examining the frogs and observing the eggs and tadpoles in space.

Then the fun part began: Students split up into small groups to examine the frogs up close. Suddenly the room was abuzz with the sound of 69 children all talking at once. Because the groups were too large for each child to do everything at each work station, they worked in teams. Navarro encouraged them to share information, as scientists do.

"That's cool," said one youngster as he used a microscope to look at frog eggs in various stages of development. Other students used pencils and paper to draw the eggs.

At another station, the kids watched tadpoles swimming in flasks. Some counted how many were in each flask, while others compared normal swimming behavior with the motion of tadpoles in space, which they had just seen in the video.

Under the watchful eye of Susan Zapalac, students at one station got to touch—carefully—some adult frogs. "They're kind of slimy," noted one child as he gingerly reached out his hand.

At another station, a parent showed students a specially designed box similar to the ones that had served as the frogs' home in space. She showed how NASA engineers had designed the box to keep the frogs comfortable by circulating fresh air through it. The students inspected the non-abrasive material lining the box, noting how it

## Mother and Tadpole Doing Fine

The Spacelab-J frog experiment that captured the nation's attention last year also made a key contribution to space biology: the first demonstration that higher life forms can reproduce in microgravity.

Once in orbit, the four adult female South African clawed frogs were injected with a hormone to stimulate ovulation. Their eggs were then collected, fertilized and allowed to hatch into tadpoles. Half the eggs were incubated in weightlessness, while the other half were spun in a centrifuge onboard the Shuttle that simulated the force of gravity on Earth. No gross abnormalities appeared in either group of tadpoles, although subtle changes at the cellular level have been detected.

"We proved that gravity does not appear to be required for ovulation, fertilization and development of this vertebrate species," reports principal investigator Ken Souza.

Behavioral studies conducted one and two days after landing indicated that tadpoles conceived and hatched in microgravity showed a stronger tracking response to a moving pattern of vertical stripes than did tadpoles reared on the centrifuge. The response of the microgravity group suggests that they may rely more on visual input, or have a higher visual acuity, than the tadpoles raised on the centrifuge. The differences had disappeared nine days after the landing, however.

The flight tadpoles have undergone metamorphosis into the frog stage and are expected to reach sexual maturity by about October. At maturity, they will be used to determine whether frogs hatched in space will breed and produce normal offspring. —*Jane Hutchison*

changed from scratchy to soft when water was added.

"Noticing the differences between these exotic frogs and typical frogs helped students understand why we had to set up their living environment in space the way we did," Navarro says.

The session concluded with a brief wrap-up of the experiment and a review of new vocabulary words learned during the session. By this time the students had no trouble explaining what "symmetry," "metamorphosis" and "microgravity" meant.

Before she left, Navarro presented each teacher and parent with a lapel pin from the mission. She also left a poster for the classroom and a resource book for the teacher. Each student got a colorful decal and a fact sheet.

What did the students think of all this? "They absolutely loved the hands-on activities," says Zapalac. "Their enthusiasm is just wonderful."

Elizabeth Bliss's sixth-graders were equally excited. "They felt this was news in the making," she says. "They were participating in a current program, not just reading about ancient history." Her students felt especially privileged to be asking questions of someone who had actually worked on a space project.

The students weren't the only ones who enjoyed the experience. "It's a real shot in the arm for the [NASA] volunteers, because we come back and realize what special jobs we have," says Zapalac.

Navarro agrees. "It was unbelievable! The energy and feeling I got after leaving that classroom was a real boost. It pumped me up."

Of course, the volunteers also provide a valuable service to the school system.

"We can give an exciting one-hour science presentation—a lot more science than most teachers have time to give," Zapalac explains.

Elizabeth Bliss found that the NASA presentation reinforced her own dedication to making sure that she and her students stay in tune with today's technology. A few weeks after Navarro's visit, her sixth-graders made a model of the Space Shuttle, using math and critical thinking skills. Follow-up discussions covered such topics as the stages of shuttle flight, eating and working in space, and health concerns.

*Students work together to answer questions about the frog experiment.*

The program also has an indirect benefit to the space agency, says Zapalac. "It's super public relations. These kids go home and tell their parents, 'NASA came to school today.'" •

*Jane Hutchison is a public affairs specialist at the Ames Research Center.*

## Keeping a Good Thing Going

Having enjoyed success with school children in her area, Susan Zapalac is working with the Educational Programs Office at Ames to make the "space frogs" program available to other NASA centers and teachers across the country. The education "modules" will include a video on the Spacelab-J frog experiment as well as additional printed instructional material.

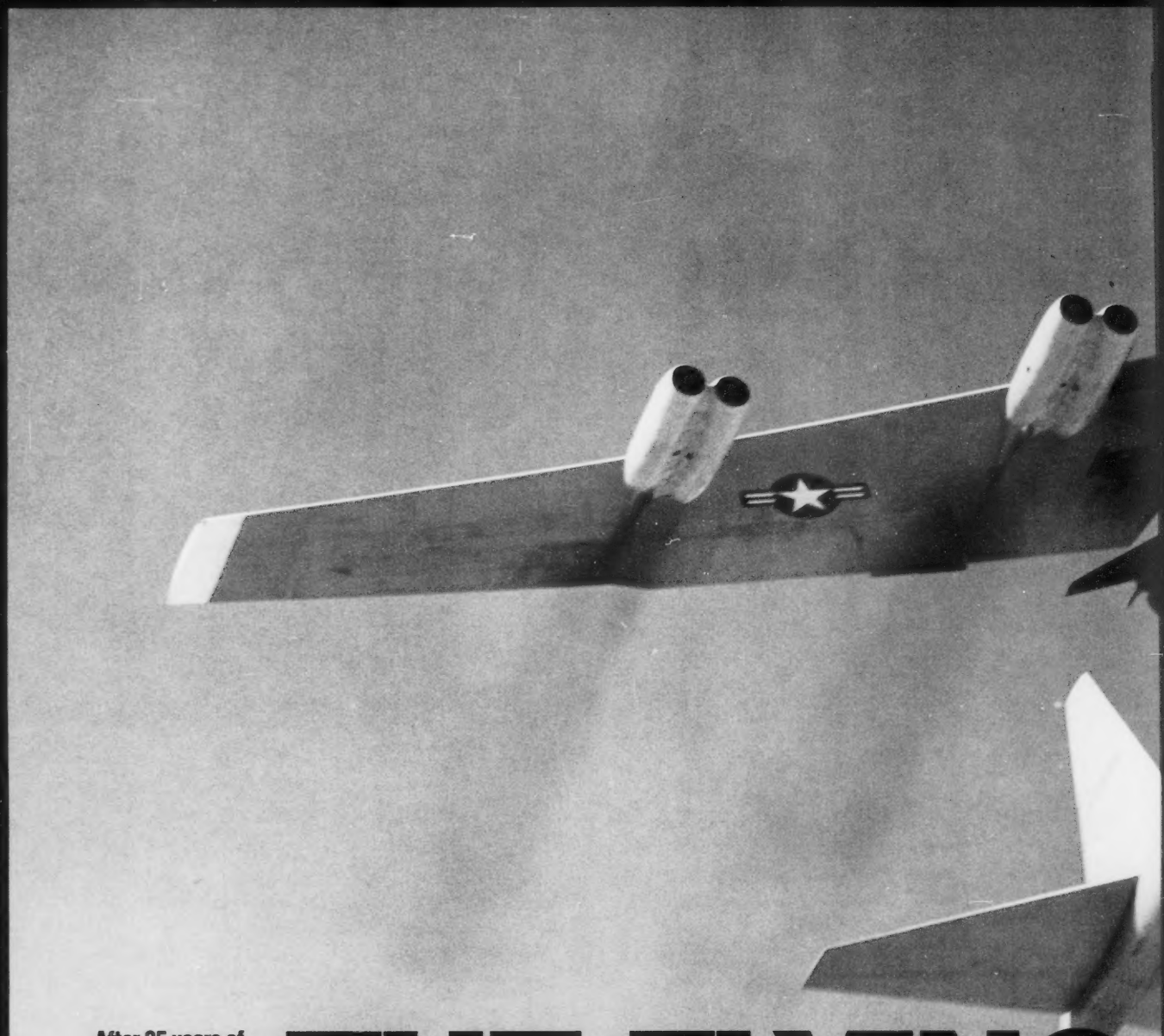
Meanwhile, local students will have yet another opportunity to learn about space life sciences research by attending the Ames Aerospace Encounter (AAE), which offers a variety of space-related educational activities for students in the fourth through sixth grades. The AAE exhibit at Ames includes a high-fidelity model of a Frog Environmental Unit (FEU) inside a space station mockup. The FEU, developed by Ames' Electronic Systems Branch, provides a temperature-controlled habitat for the frogs and developing tadpoles.

"This module requires students to use a variety of skills, including math, graphing and observation," says Julie Shultz, the AAE program coordinator. With the help of a computer program, students can observe the growth cycle of frogs and compare their behavior in two environments (microgravity and normal Earth gravity).

Other Ames volunteers are looking into expanding the outreach project to different audiences, including engineering students at the University of Southern California and the University of California at Berkeley, and visitors to the Exploratorium, a hands-on science museum in San Francisco.

*—Jane Hutchison*

*Students cautiously reach out to touch one of the frogs, carefully held by Susan Zapalac, as a parent looks on.*



**After 35 years of NASA service, the oldest B-52 in the sky is still delivering the goods.**

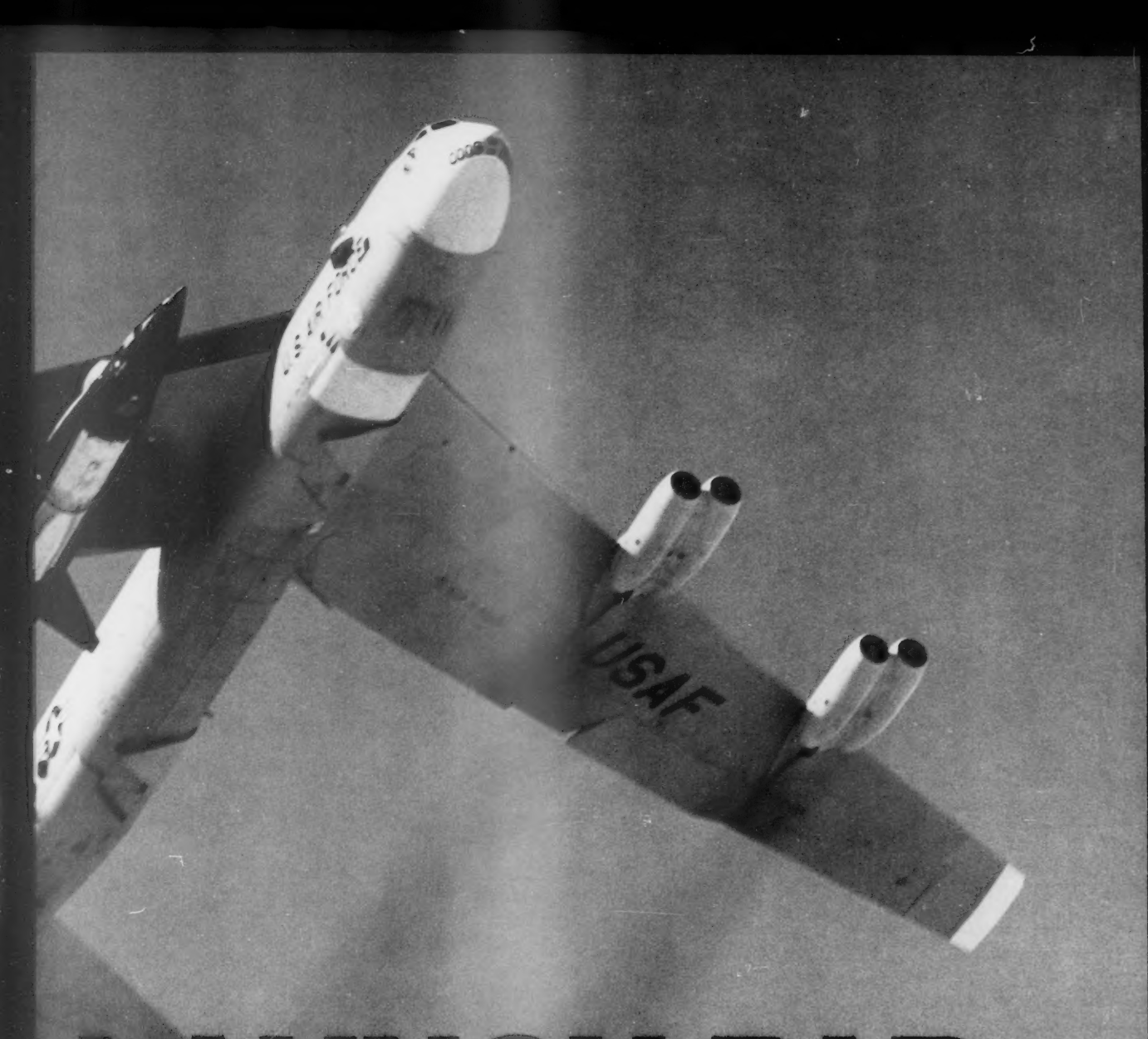
# THE FLYING

by Linda Faulhaber

With a wing span wider than a football field and eight turbojet engines that make enough noise to rattle your fillings, it's hard *not* to notice NASA's B-52B research aircraft as it taxies down the runway at the Dryden Flight Research Facility. But even though the plane—the oldest B-52 still flying—has been launching rocket planes and space boosters for more than 35 years, it has never received much glory. Never mind that many research projects would never have gotten off the ground without it.

"This bomber has been a part of NASA's history and the history of Edwards Air Force Base," says Roy Bryant, Dryden's B-52 program manager. "It represents a lot of successful programs that have contributed to the advancement of military and civilian aircraft."

"I haven't flown another airplane with so much history," agrees Gordon Fullerton, a former Space Shuttle astronaut and one of three NASA research pilots currently flying the plane.




# LAUNCH PAD

Built in 1952, the aircraft was only the eighth B-52 and the fifth of 10 B-model planes to roll off the assembly line at the Boeing Aircraft Corp. in Seattle. The airplane is still referred to by its original number: "Double-Oh-Eight."

After a four-year stint as an Air Force test aircraft at Edwards, the B-52B began nearly a decade of service in the historic X-15 rocket research program. To convert the bomber to a flying launch pad (the X-15s rocketed to the edge of space after being dropped from a carrier plane), a number of modifications had to be made, such as cutting a large notch in its right inboard wing flap to accommodate the X-15's vertical tail.

Double-Oh-Eight was one of two B-52s used as motherships for the X-15 program. The converted bomber air-launched 106 of the 199 flights between 1959 and 1968, some of which set aircraft altitude and speed records that still stand. A logo on the fuselage shows a caricature of the B-52, with one wing poised to throw an X-15 rocket the way a

quarterback would throw a football.

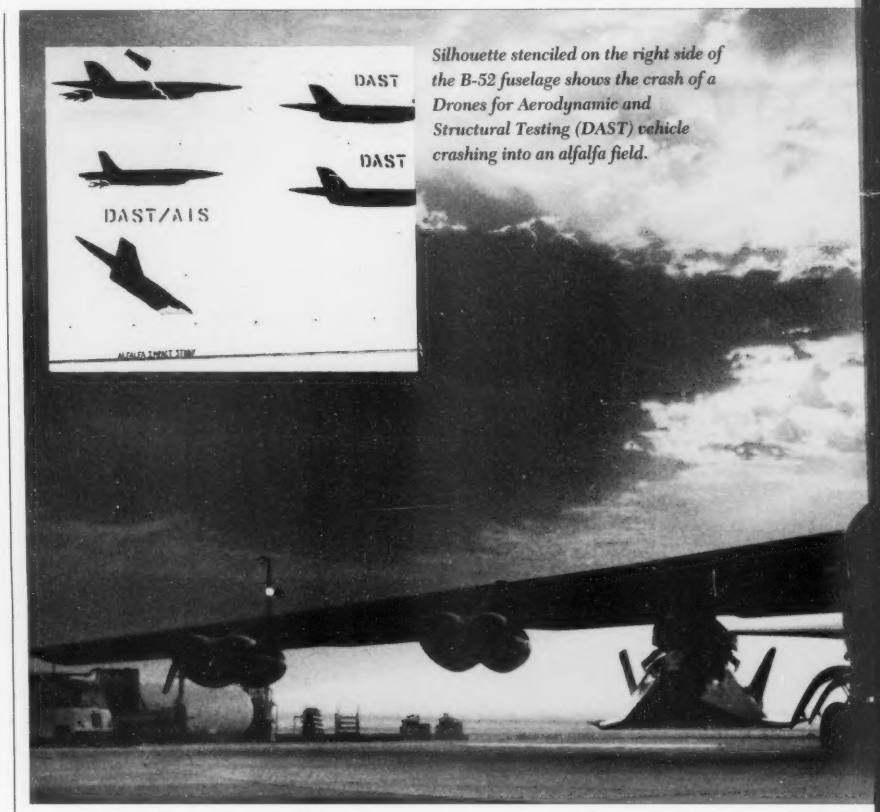
Retired Air Force and NASA research pilot Fitz Fulton was at the controls during most of the X-15 releases.

"It was a great feeling as soon as the X-15 was dropped," he recalls. "If it was a heavy one, you'd really feel a thump and the aircraft would roll to the side. Once they'd let go, our job was done, except we'd listen for the sound of the rocket engine igniting. We'd watch the X-15 accelerate out in front of us. By the time it went through our altitude it would be a half-mile ahead of us and we'd watch the contrails."

When the X-15s stopped flying in the fall of 1968, the program's other B-52, Number 003, was retired. Double-Oh-Eight came close to meeting the same fate, but was saved from the scrap heap when NASA found another need for the aircraft's unique carrier capabilities—launching the odd, flat-bottomed aircraft known as "lifting bodies." Like the X-15 flights, these experiments contributed important data that were later used in developing the Space Shuttle.

Dryden chief engineer Milt Thompson, at one time chief pilot of the lifting body program and one of 12 men to fly the X-15, said the most tiring part of any air-launched flight for the pilot inside the "passenger" vehicle was the 45 minutes he sat waiting for the B-52 to reach the launch altitude of 45,000 feet.

It was usually a smooth ride, though, "and you did get to do some sightseeing on the way to the launch point," adds Thompson. "Luckily, you were very busy prior to launch and did not have time to become apprehensive about it. Once you launched, there was no turning back. You were committed; ready or not."




*Silhouette stenciled on the right side of the B-52 fuselage shows the crash of a Drones for Aerodynamic and Structural Testing (DAST) vehicle crashing into an alfalfa field.*

During the 1970s, the B-52 air-launched several remotely piloted vehicles, including the subscale F-15 spin recovery vehicle, which was used to study stability and controllability in fighter jets. Beginning in the late 1970s and continuing into the mid-1980s, Double-Oh-Eight also played a part in the Shuttle development program, testing the parachute recovery system for solid rocket booster casings and helping engineers to evaluate the practicality of unpowered Shuttle landings. For the landing tests the giant bomber descended with its landing gear extended, all spoilers fully deployed, and all engines at idle power.

"The B-52 really came downhill in a hurry in that configuration," remembers Thompson. More recently, the plane was used to test a drag chute system for Shuttle landings.

**"I haven't flown another airplane with so much history," says former astronaut Gordon Fullerton.**

NASA has not been the only organization to enlist the plane's service. The Air Force has relied on the B-52B since early 1979 to air drop F-111 crew escape modules to help engineers improve their performance. A fourth series of tests began in 1991.

Private industry also has used the B-52B as a carrier. In 1989, Double-Oh-Eight was instrumented to carry the Pegasus space booster for the Orbital Sciences Corporation. A year later the plane, with Gordon Fullerton in the pilot's seat, air-

*The Pegasus air-launch space booster being carried aloft by the B-52 carrier.*

*Sergio Factuar, one of three maintenance personnel assigned to the B-52; most instrumentation pictured in the cockpit is original.*

launched the first Pegasus from about 60 miles southwest of Monterey, off the California coast. The launch further distinguished the B-52B as the only aircraft to send a payload into Earth orbit. The second Pegasus launch in July 1991 marked the 900th flight for the B-52B. Two more have since been launched, one over the Atlantic Ocean in February of this year, and the most recent over the Pacific in April.

Silhouettes stenciled on the right side of the fuselage tell the story of all the historic test vehicles the B-52B has lifted to great heights over the years. Not all the missions ended with high-fives. One notable failure was the remotely piloted Drones for Aerodynamic and Structural Testing (DAST) vehicle that crashed into an alfalfa field. The silhouette for DAST shows the tail of the test aircraft sticking out of the ground with the words, "Alfalfa Impact Study" underneath. Also marked on the fuselage is the "Dumpster Impact Study Area," where workers had to patch after a wind gust blew a dumpster into the side of the B-52B.

As of this spring, Double-Oh-Eight had completed 922 missions, but it wasn't certain how long the air-launcher would remain in service. A B-52G loaned to NASA in 1990 may be converted as a replacement. The G model, a former test aircraft at Edwards, remains in flyable storage at Dryden.

Although Double-Oh-Eight has racked up relatively few flying hours—a little over 2,200—the three ground maintenance personnel assigned to it are constantly jumping hurdles to keep it flying. Roy Bryant attributes the plane's 98 percent mission success rate since 1987 to this dedicated maintenance team, who are well known for their ability to scrounge spare parts, whether it's from a local "bone yard" or a museum in Arizona.

While the landing gear, engines, ejection seats and brakes of the B-52B have been updated, much of the plumbing, cable, wiring, ducting and instruments are original World War II-era technology. Crew members jokingly say that the electrical system looks like something out of Frankenstein, "with bolts of lightning flying out."

"Every time it takes off you feel like you got away with something," says Mike Bondy, who was crew chief for 10 years and part of the third generation of ground personnel to work on the aircraft.

"The whole crew takes care of the airplane like they would a classic car," he adds.

The aircraft has outlived other B models by more than a quarter of a century: All but Double-Oh-Eight were sent to storage by 1966.

"It's a good airplane," says current crew chief Dan Bain. "I wouldn't want to work on anything else."

When retirement day finally comes, many of the people who have been associated with the B-52B over the past four decades would like for it to be displayed at Dryden.

"I'd like to see it on a pedestal right out in front of the [main building at the facility]," says Bondy.

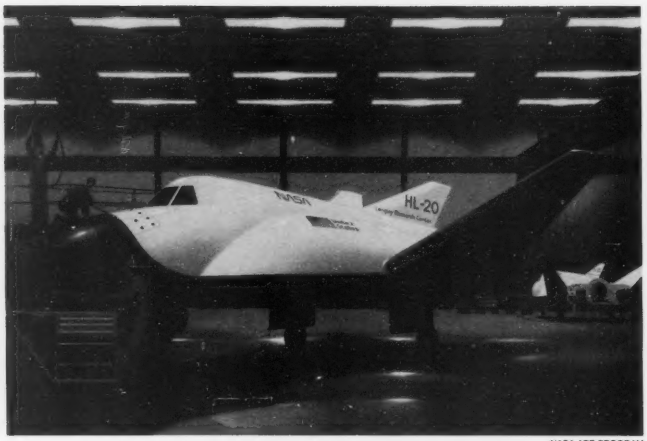
There's no way 85 tons of metal could be overlooked there. •

*Linda Faulhaber is a former public affairs officer at the Dryden Flight Research Facility.*

**Langley**

### Gimme Five

This painting of the Langley Research Center's proposed personnel launch system is one of five recently created by artist Stan Stokes for the NASA Art Program. All five paintings are on display at Langley's official visitor center, the Virginia Air and Space Center in Hampton, Virginia. "HL-20 in the Hangar" shows the vehicle being serviced in a conventional hangar. The HL-20, one of several designs being considered by NASA as a complement to the Space Shuttle, may be used one day to transport up to 10 astronauts and small cargo to and from low Earth orbit. The vehicle would be launched by an expendable rocket and would use its own propulsion system to rendezvous with the space station. Following an exchange of crews or cargo delivery, the HL-20 would then return to Earth like the Space Shuttle, making a runway landing near the launch site. •




NASA ART PROGRAM

**Goddard**

### A SPARTAN Recovery

One of the more intriguing payloads onboard last April's STS-56 Space Shuttle mission was the SPARTAN satellite—a self-contained, free-flying platform that measured the solar wind and the Sun's corona while orbiting separately from Discovery. The SPARTAN operated completely independently after it was released from the Shuttle, using its own battery-powered pointing system and recorder for capturing data.

SPARTAN's two telescopes observed the Sun's corona for approximately 40 hours during the flight. Data from the White Light Coronagraph and the Ultraviolet Coronal Spectrometer allowed scientists to measure for the first time electron and proton temperatures and densities in the solar corona. Mission control reported during STS-56 that all activities involved with SPARTAN's deployment and retrieval went exactly as planned. The SPARTAN carrier and instrument are scheduled to fly again on STS-63 in May 1994 and STS-76 in June 1995. •

*SPARTAN-201 is backdropped against heavy cloud cover over the Mediterranean Sea during the STS-56 mission in April.*

**JPL**

### Trainable Tools

Scientists at the Jet Propulsion Laboratory and the California Institute of Technology announced in April that they have developed a computer software system to catalog and analyze the estimated half billion objects in the second Palomar Observatory sky survey. The system, called Sky Image Cataloging and Analysis Tool (SKICAT), is based on state-of-the-art machine learning, high performance database and image processing techniques. According to Usama Fayyad of JPL, the core of the new system lies in two integrated machine learning mathematical formulas, or algorithms, that automatically produce decision trees for the computer. A machine learning program "learns" to classify new data based on training data or examples provided by human experts.

Fayyad and Caltech astronomer Nick Weir said SKICAT has a correct object classification rate of about 94 percent, better than the 90 percent rate needed for accurate scientific analysis of the data. By contrast, Fayyad says, the best performance of a commercially available learning algorithm is about 75 percent. Fayyad believes that SKICAT represents a new generation of intelligent trainable tools for dealing with the huge volumes of scientific imaging data collected by modern instruments. •

## Goddard-Wallops

### The Hub of Things

The Wallops Range Control Center served as the hub of mission operations during last February's launch of the Orbital Sciences Corporation's Pegasus air-launched booster over the Atlantic. The Pegasus carried the Brazilian SCD-1 environmental satellite, which is dedicated to the collection and distribution of environmental data. The satellite receives weather and environmental data from as many as 500 data collecting platforms distributed over Brazilian territory. Approximately 11 minutes after the Pegasus was released from a B-52 aircraft, the SCD-1 satellite was placed in a nearly circular orbit at an altitude of 750 kilometers. •

*The Pegasus booster was released from Dryden's B-52B aircraft. (see page 30 for the story of the B-52)*

## Stennis

### Supporting the Community

Stennis Space Center released in April the findings from an economic impact study that details the center's influence on its local economy. The study, which was presented at Stennis' annual community leaders briefing, found that during fiscal year 1992 the center had a total impact of $349 million in Mississippi and Louisiana. Within 50 miles of the space center, the economic impact was $252.6 million.

NASA gathered and compiled economic data from all resident agencies and contractors at Stennis, then provided it to Mississippi State University, which did the economic analysis. The study estimated that without Stennis, there would have been 14,916 fewer local jobs last year. In Mississippi alone, Stennis paid in excess of $172.8 million for direct and indirect salaries and $113.4 million for goods and services in fiscal year 1992. In addition to the 2,979 Stennis employees that resided in the state last year, an additional 7,279 jobs were created in local communities, in direct and indirect support of the center's work. •

*A Stennis engineer briefs local leaders about the Space Shuttle Main Engine during the community leaders briefing on April 20.*

## Ames-Moffett

### Joining Forces

NASA signed an agreement in March with Learjet, Inc., of Wichita, Kan., to work together on technologies and methods for developing and testing a new high-performance business jet. Engineers from the company and NASA would conduct research using state-of-the-art supercomputers and wind tunnels at the Ames Research Center.

The first year of the joint research program will cost about $2 million for development and testing of a wind tunnel aircraft model built by Learjet. The tests, for which NASA will contribute 480 hours of wind tunnel time, are scheduled to begin in January. If the results are commercially viable, Learjet will cover the cost of developing and flight-testing a prototype aircraft.

Under the agreement, NASA and Learjet will share test data, computer programs and design methods during the cooperative project. Any new design methods that result will be offered to all U.S. aerospace companies. •

## Lewis

### People Power

A team of engineers from the Lewis Research Center's Power Technology Division recently helped a group of scientists from NASA and the National Science Foundation extend their field studies near Lake Hoare, an ice-covered lake in the valleys of southern Victoria Land, Antarctica.

According to Lisa Kohout, a member of the six-person Lewis team, "The researchers in Antarctica had been using diesel generators and were concerned about the environmental impact of a fuel spill. They were eager to see a demonstration system they could use at the field camps that would serve as a prototype for larger scale bases."

Conceived and built within 15 months, the 1.5-kilowatt modular power system consists of silicon solar cells that capture the Sun's energy, coupled with a battery pack and an electrical distribution system. The system, which has already exceeded performance expectations, has been supplying the Antarctic research team since last August with electricity for personal computers and printers, lab equipment, lights, fans and even a microwave oven. •

**With the end of the Cold War, NASA's mission is changing. But the civil space program remains as important as ever to our nation's sense of adventure and discovery, as well as to its technological competitiveness.**

## After the Space Race

by Terence T. Finn, NASA Hq.

The Apollo expeditions to the Moon proved the technical superiority of the United States over the Soviet Union, leaving no doubt that free societies could compete technologically with totalitarian states. Yet NASA was more than simply an agent of the Cold War. It also reflected the age-old need to learn more about the Universe in which we live. The Pioneer and Voyager missions, the Hubble Space Telescope and the Gamma Ray Observatory all are missions of discovery, intellectual endeavors that expand the storehouse of human knowledge.

NASA, a civil space organization, is our response to this human imperative to explore. The mission is conceptually simple, but difficult to pull off. It is intellectually rigorous, but enormously satisfying.

Yet there is also an element of adventure in space exploration. We send astronauts into space to expand human experience, and those of us who sit safely on the ground marvel at the audacity of those who fly. Talking about adventure in the course of serious public policy debates is unusual, so it generally gets ignored. Fortunately, people outside Washington understand the importance of adventure, and it remains an unspoken force that drives the NASA enterprise.

Now that the Cold War has ended, political justifications for NASA seem much less compelling. We no longer need a civil space program to impress the Russians or anyone else, including ourselves. After the display of U.S. military might in the Gulf War, the technological capabilities of the United States are well understood in every corner of the globe. Concerns about national security remain critical, but the civil space program is not an essential element of that concern.

Why then have a NASA?

Part of the answer lies in a broader definition of national security. No longer limited to just military might, national security now includes economic competitiveness as well. Our country is not secure if our industries cannot compete. Our people are not safe if jobs and customers are lost to companies overseas.

In the 1990s the principal threats to America are economic. These threats, whether they come from Europe or the Pacific Rim, must be met with economic growth, and the engine of economic growth is technology.

The space program both drives and requires advanced technologies. It is impossible to explore Saturn or operate the Space Shuttle without them. Remote sensing systems, new materials and computers are only three of the technologies that NASA, in partnership with industry and academia, advances as it goes about the business of conducting the nation's civil space program.

The technologies that Wall Street analysts lump together in the general category of "aerospace" are critically important to this country. As the defense industrial base declines, the space program helps to sustain the companies and skills that make up that base. For the most part, they are the same companies and skills needed for space exploration. If we build fewer F-15s and Abrams tanks, we should be building more Mars Observers and a more capable space station.

The quest for new knowledge remains strong. So too does the spirit of adventure. Yet it is the technological character of the space program, its relevance to manufacturing and productivity, that makes NASA an important player in America's renewal.

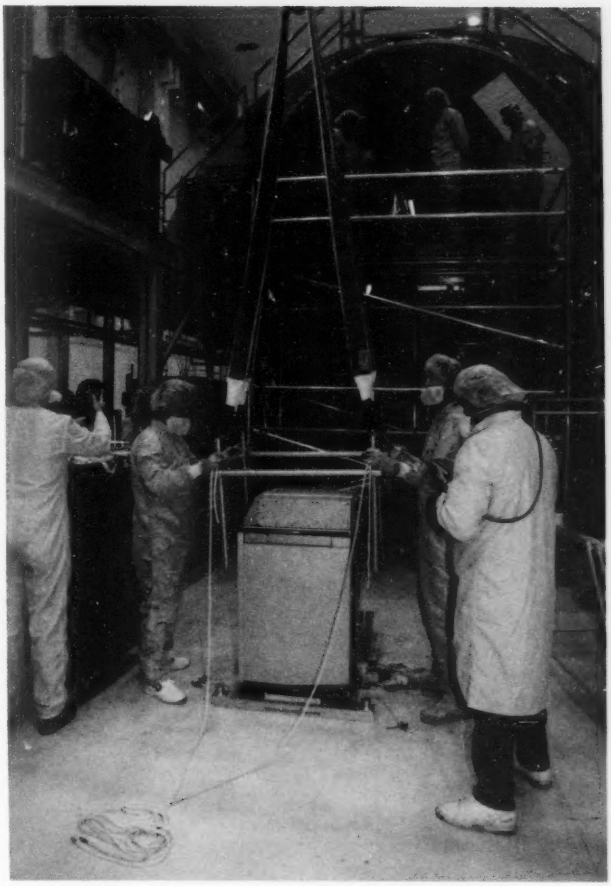
Conducting a space program worthy of our past will be difficult. Yet only a difficult space program is worth doing. It will challenge us technologically, forcing us to be both clever and efficient, enabling us to compete in the years ahead.

And if, as in the past, the agency continues to inspire the young, if children look to the stars and decide to be part of an adventure that adds to human knowledge and safeguards our country, then that may be one of the greatest benefits of all. •

*Dr. Terence T. Finn is Senior Policy Analyst in the Office of Policy Coordination and International Relations.*

## LAUNCHES

• STS-58 — Space Shuttle Columbia will carry Space Life Sciences 2 (SLS-2) on this scheduled 13-day mission. (Photo at right shows KSC workers installing a refrigerator and a freezer in the SLS-2 module)



## EVENTS

**10**
**AUGUST**

First anniversary of the TOPEX/POSEIDON launch.

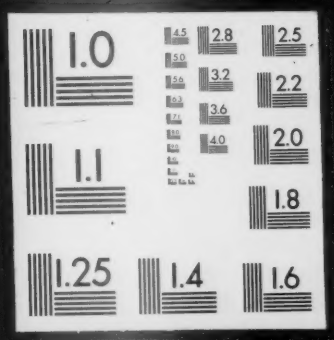
**25**
**SEPTEMBER**

First anniversary of the launch of Mars Observer.

## IN OUR NEXT ISSUE

The Hubble Space Telescope gets a service call.

National
Aeronautics and
Space
Administration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